SMC Standard SMC-S-012
16 January 2015

Supersedes:
SMC-S-012 2008

Air Force Space Command

SPACE AND MISSILE SYSTEMS CENTER STANDARD

SOFTWARE DEVELOPMENT

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
16 JAN 2015	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Space and Missile Systems Center Standard: Software Development	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **USAF Space and Missile Systems Center SMC/EN Los Angeles Air Force Base 483 N. Aviation Blvd El Segundo, CA 90245-2808**	8. PERFORMING ORGANIZATION REPORT NUMBER **SMC-S-012 (2015)**
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**192**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

FOREWORD

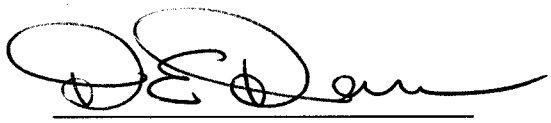
1. This standard defines the Government's requirements and expectations for contractor performance in defense system acquisitions and technology developments.

2. This revised SMC standard comprises the text of The Aerospace Corporation report number TR-RS-2015-00012, entitled *Software Development Standard for Mission Critical Systems.* The major changes in this release are documented in the Change Log contained in this document.

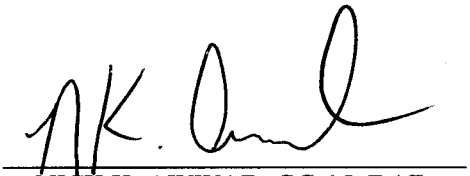
3. Beneficial comments (recommendations, changes, additions, deletions, etc.) and any pertinent data that may be of use in improving this standard should be forwarded to the following addressee using the Standardization Document Improvement Proposal appearing at the end of this document or by letter:

Division Chief, SMC/ENE
SPACE AND MISSILE SYSTEMS CENTER
Air Force Space Command
483 N. Aviation Blvd.
El Segundo, CA 90245

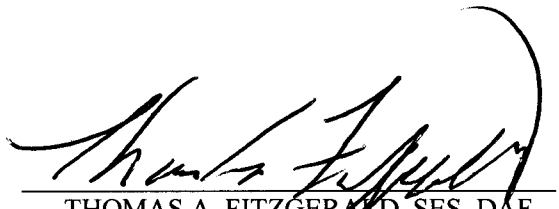
4. This standard has been approved for use on all Space and Missile Systems Center/Air Force Program Executive Office - Space development, acquisition, and sustainment contracts.



DAVID E. DAVIS, GG-15, DAF
SMC Chief Systems Engineer



NICK K. AWWAD, GG-15, DAF
Systems Engineering Division Chief



THOMAS A. FITZGERALD, SES, DAF
SMC Director of Engineering

Change Log

Issue	Date	Sections	Changes
Initial TOR-2004 (3909)-3537	20 July 2004	All	Based on MIL-STD-498 and tailoring for J-STD-016 in Recommended Software Standards for Space Systems TOR-2004(3909)-3406.
Rev A	11 March 2005	5.1.1	Reference to Appendix H instead of SDP DID.
		6.2	Replaced SDP DID with "Use Appendix H."
		Appendix H	Added Appendix H SDP Template.
Rev B	11 March 2005 (Editor provided November 2005)	None	Distribution became public unlimited. No content change was made. Date remains the same. Published by SMC as SMC-S-012 (2008)
TOR-2013-00083	March 28, 2013	Title	Changed title from "Software Development Standard for Space Systems" to "Software Development Standard for Mission Critical Systems" to better reflect the domains covered. Changed report numbering to TOR-2013-00083.
		Foreword and Introduction	Deleted.
		Many	Incorporated tailoring and lessons learned from recent acquisitions.
		All	All requirements were assigned unique identifiers within their subsections.
		All	All multipart requirements were split and assigned unique identifiers within their subsections.
		Most	Deleted all extra shall statements that merely required other shall statements to be met. (No double counting.)
		1	Updates to acquisition- and contract-related terms.
		2	Deletions, additions, and updates to referenced documents.
		3.1	Additions and updates to software terms for clarification.
		4.2.3	Updates and additions to software bidirectional traceability. All traceability requirements were gathered in this subsection.
		4.2.4	Updates and additions to reusable software products.
		4.2.5	Updates and additions to assurance of critical requirements.
		4.2.8	Updates and additions to access for acquirer review.
		4.2.9	Added contractual requirements for software.
		5.1 and 5.2	Updates to software test planning and integration and test environments.
		5.3	Updated requirements for system requirements analysis.

Issue	Date	Sections	Changes
		5.4	Updated requirements for system architectural design.
		5.5	Updated requirements for software requirements analysis.
		5.6	Major update to software design to add software architecture and rewrite software design.
		5.7 – 5.11	Major updates to improve the robustness of software testing at several levels from unit testing to system qualification testing.
		5.12	Updated requirements for transition to operations.
		5.13	Updated requirements for transition to maintenance.
		5.14	Added requirements for configuration management baselines and clarified requirements for other configuration management aspects.
		5.15	Updated and added requirements for peer reviews.
		5.16	Updated and added requirements for quality assurance.
		5.17	Updated requirements for corrective action.
		5.18	Updated requirements for joint technical and management reviews.
		5.20	Replaced requirements for software measurement.
		5.22	Replaced requirements for subcontractors with requirements for software team members.
		5.24	Updated requirements for coordination with associate developers.
		5.25	Added requirements for process improvement and Process Improvement Plan.
		6	Updated information for current acquisition practices. Included and updated information from old Appendix G. Added references to new templates in Appendix H.
		Appendix A	Updated acronym list.
		Appendix B	Made mandatory and updated evaluation criteria for reusable software.
		Appendix C	Made mandatory and added discrepancy and change report requirements.
		Appendix D	Reformatted for easier understanding and added more product review criteria.
		Appendix E	Made mandatory and added build reviews and objectives.
		Appendix F	Replaced guidance for software indicators with mandatory test log requirements.
		Appendix G	Deleted all content.
		Appendix H	Made mandatory and updated Software Development Plan template (H.1) to match updates to standard and provide project information. Added templates for Software Architecture Description, Software Master Build Plan, Software Measurement Plan, Software Measurement Report, and Process Improvement Plan.

Issue	Date	Sections	Changes
TR-RS-2015-00012	17 March 2014	Most	Addressed comments from industry reviewers throughout the document. (Industry and stakeholder review is documented in TOR-2013-00797 Rev A.)
		1.2.5.6 #6a	Removed “validating” other software.
		3.1	Changed definitions of discrepancy, software development file, and added definition of demonstrate, stakeholder, and turnover. Clarified definitions of a few other terms, e.g., software development file, target computer system ,test procedures.
		4.2.3	Clarified bidirectional traceability.
		5.9.3	Updated and clarified advance notice for software qualification testing and related events.
		5.15.1	Simplified peer review data references.
		Appendix E	Added advance notification to acquirer for technical reviews.

Contents

Tables

1. Scope

1.1 Purpose

The purpose of this standard is to establish uniform *requirements* for *software development* activities for mission critical *systems*.
Note 1: Terms that appear in *italics* are defined in Section 1.2 or Section 3.1 Terms.
Note 2: This standard is based on (DOD MIL-STD-498).

1.2 Application[1]

This standard applies to the development of mission critical *systems* that contain *software* (such as hardware-software systems), *software-only systems*, and stand-alone software *products*. The application of this standard is intended as in the following paragraphs.

1.2.1 Organizations and Agreements

This standard can be applied to contractors or *acquirer* in-house agencies performing *software development*. Within this standard, the term "*acquirer*" is used for the organization requiring the technical effort (see Section 3.1); the term "*developer*" is used for the organization(s) performing the technical effort (see Section 3.1); the term "*contract*" is used for the agreement between these parties (see Section 3.1); the term "Statement of Work" (SOW) is used for the list of tasks to be performed by the *developer*; and the term "Contract Data Requirements List" (CDRL) is used for the list of *deliverable products*.

1.2.2 Contract-Specific Application

This standard is invoked by citing it on a *contract* as a compliance document. It applies to each *product* and to each *category of software* covered by the *contract*, regardless of storage medium. The *acquirer* is expected to specify the *categories of software* to which the standard applies and to tailor the standard appropriately for each *category of software*. While this standard is written in terms of *software items*, it applies to *software* within the covered *categories of software* that is not designated as a *software item*, with the term "software item" interpreted appropriately. This standard applies to *software* installed in *firmware* devices.

This standard applies to the *prime contractor* and all *software team members*. This standard applies to the *categories of software* defined in Section 1.2.5.

1.2.3 Tailoring

This standard can be tailored for each *category of software* to which it is applied. General tailoring guidance can be found in Section 6.5.

1.2.4 Compliance[1]

1.2.4.1 Compliance Definition

Compliance with this standard as tailored for a project and recorded in the *contract* is defined as:

1. Performing the activities that resulted from tailoring this standard for a specific project, and
2. Recording *applicable* information resulting from the performance of the activities.

An activity is complete when all actions constituting the activity, as specified in the *contract*, have been accomplished and all *applicable* information has been *recorded*.

1.2.4.2 Compliance Terminology

For this standard, the words "shall," "should," and "may" are reserved words used to designate different levels of compliance. The term "shall" is used in statements of mandatory *requirements*. The term "should" is used to indicate a goal that the *developer* should attempt to adhere to, if at all

[1]This subsection is based on information from Section 1 of (EIA/IEEE J-016).

possible. The term "may" is used to indicate an optional method of satisfying a *requirement*. Use of the simple present and future tenses is limited to descriptive information only. In particular, the terms "will" and "must" are not used in this standard for any level of compliance.

1.2.4.3 Order of Precedence

In the event of conflict between the *requirements* of this standard and other mandatory standards, the *acquirer* is responsible for resolving the conflicts.

1.2.5 Interpretation of Selected Terms

Terms that appear in *italics* are defined in Section 1.2 Application or Section 3.1 Terms. The following terms have a special interpretation as used in this standard.

1.2.5.1 Interpretation of 'System' and 'Subsystem'

The following interpretations of the words "system" and "subsystem" apply:

1. The term "system," as used in this standard, means:
   a. A software-hardware system (for example, a radar system) for which this standard covers only the software portion, or
   b. A software system (for example, a mission planning system, or *software* running on the *acquirer's* computers) for which this standard governs overall development.
2. The term "subsystem" is used to mean any system *component* between the entire *system* and the individual *software items* and *hardware items*. Depending on context, these *components* could be called subsystems, segments, elements, prime items, critical items, complex items, or other *acquirer*-specific terminology. For example, a *system* could consist of segments; a segment could consist of subsystems or elements; and a subsystem or element could consist of *software items* and *hardware items*.
3. If a *system* consists of *subsystems*, all *requirements* in this standard concerning *systems* apply to the *subsystems* as well. If a *contract* is based on alternatives to *systems* and *subsystems*, such as segments or complex items, the *requirements* in this standard concerning the *system* and its *specification* apply to these alternatives and their *specifications*.

1.2.5.2 Interpretation of 'Participate' in System Development[1]

The term "participate" in sections regarding *system* or *subsystem* activities is to be interpreted as follows:

1. If the *software* covered by this standard is part of a hardware-software *system* for which this standard covers only the software portion, the term "participate" depends upon what organization is in charge of the activity:
   a. If the activity is performed by the software organization, then "participate" is to be interpreted as "be responsible for."
   b. If the activity is performed by another organization such as an integration and test organization, then "participate" is to be interpreted as "take part in."
2. If the *software* (possibly with its computers) is considered to constitute a *system*, the term "participate" is to be interpreted as "be responsible for."
3. If the *software* in a hardware-software *system* is modified, but the hardware is not, the term "participate" is to be interpreted as "be responsible for."

1.2.5.3 Interpretation of 'Develop,' 'Define,' Etc.

Throughout this standard, *requirements* to "develop," "define," "establish," or "identify" information are interpreted to include new development, modification, reuse, *reengineering*, *maintenance*, or any other activity or combination of activities resulting in *products*. Within this standard, *requirements* to "develop," "define," "establish," or "identify" always include recording the information even if that is not explicitly stated. These terms also include maintaining the previous and current information, software products, facilities, infrastructure, software development environments, capability, etc.

throughout the system development lifecycle. Maintaining the development environments includes such activities as maintaining configuration management over all components of the development environment; keeping the configurations current; keeping the versions of *reusable software*, including *commercial off-the-shelf (COTS) software*, current so that *supplier* support is maintained; and keeping the plans and procedures current.

1.2.5.4 Interpretation of 'Record' or 'Document' (the Verbs)

Throughout this standard, *requirements* to "record" or "document" information are interpreted to mean "set down in a manner that can be retrieved and viewed." The result can take many forms, including, but not limited to, hard copy or electronic documents and data recorded in computer-aided engineering (CAE) and project management tools. This interpretation also applies to implicit *requirements* to record or document as described in Section 1.2.5.3.

1.2.5.5 Interpretation of 'Applicable'[1]

Within this standard, *requirements* to provide "applicable" information or to perform "applicable" activities are interpreted as meaning to "provide the information or perform the activities that are required for the project in accordance with the methods, tools, and procedures explained in the Software Development Plan." The term "applicable" suggests that not all development projects will require the information or the activity. The *acquirer* and the *developer* jointly agree upon whether providing information or performing activities are applicable.

1.2.5.6 Interpretation of 'Categories of Software'

The standard applies to the following categories of *software* including the *software* portion of *firmware*:

1. *software* onboard space vehicles (e.g., spacecraft bus, communications, payload);
2. *software* onboard launch and upper-stage vehicles;
3. ground operations *software* (e.g., mission planning; mission data processing; mission data distribution; mission data storage; mission support; telemetry, tracking, and commanding; infrastructure and services);
4. user equipment *software* (e.g., *software* embedded in ground terminals, handheld receivers, receivers onboard wheeled vehicles, spacecraft, aircraft, ships, and weapons);
5. *software* that allows configuration management of initial and updated data, including constants, command sequences and procedures, and computer instructions, stored in onboard, ground, and user equipment *databases* or other types of data stores, and *software* that supports the *verification* and *validation* of this data; and
6. other *software* (e.g., applications, security, safety, training, modeling, simulation, analysis, database support, automatic test equipment, test facility and environment, and *maintenance*) used in any of the following:
    a. satisfying or verifying *requirements, or*
    b. performing or supporting operations.

1.2.5.7 Interpretation of 'User'

Within this standard, the term "users" includes operators of the *system* in addition to the end users of the data produced by the *system*.

1.2.5.8 Interpretation of 'User Site'

Within this standard, the term "user site" is interpreted to include individual ground operations sites, individual space vehicles, individual launch vehicles, individual mobile ground systems, and individual types of user equipment. This term is used primarily in Section 5.12.

1.2.5.9 Interpretation of 'Prime Contractor'

Within this standard, the term "prime contractor" is interpreted to mean the organization with which the *acquirer* has the prime *contract* for the project. The prime contractor can also be the *developer*.

1.2.5.10 Interpretation of 'Subcontractor'

Within this standard, the term "subcontractor" is interpreted to mean any *software team member* tasked by the *prime contractor* or another *software team member* to perform part of the required software-related effort. This definition is broader than the usual legal definition of subcontractor.

1.3 Method and Tool Independence

This standard is independent of any particular *software development* methods or tools. No *requirement* in this standard mandates that a particular method or tool be used.

2. Referenced Documents

Abelson 2011. Abelson, L. A., S. Eslinger, M. C. Gechman, C. H. Ledoux, M. V. Lieu, K. Korzac, *Software Measurement Standard for Space Systems*, Aerospace Report No. TOR-2009(8506)-6, 5 May, 2011, The Aerospace Corporation.

Adams 2002. Adams, R. J., and S. Eslinger, *A Framework for Software Products Within a System Context (2nd Edition)*, Aerospace Report No. TR-2002(8550)-3, 31 May 2002, The Aerospace Corporation.

Avizienis 2004. Avizienis A., J.-C. Laprie, B. Randell, and C. Landwehr, *Basic Concepts and Taxonomy of Dependable and Secure Computing*, IEEE Transactions on Dependable and Secure Computing, Vol. 1, No. 1, 2004.

CNSSI 4009 2010. Committee on National Security Systems, *National Information Assurance (IA) Glossary,* CNSS Instruction No. 4009, 26 April 2010.

Cohen 2005. Cohen, J., D. Plakosh, K. Keeler, *Robustness Testing of Software-Intensive Systems: Explanation and Guide*, Report No. CMU/SEI-2005 -TN-015, April 2005, Carnegie Mellon University.

DAU Glossary. Defense Acquisition University, *Glossary: Defense Acquisition Acronyms and Terms, Eleventh Edition*, September 2003.

Dixon 2006. Dixon, J. M., C. M. Rink, and C. V. Sather, *Digital ASIC/PLD Development Handbook for Space Systems*, Aerospace Report No. TOR-2006(3904)-1, 19 May 2006, The Aerospace Corporation.

DOD DAU 2001. Systems Management College, *Systems Engineering Fundamentals*, January 2001, Defense Acquisition University.

DOD MIL-STD-498. Department of Defense, *Software Development and Documentation*, MIL-STD-498, December 1994.

DOD-CIO 2009. Chief Information Officer, *Clarifying Guidance Regarding Open Source Software (OSS)*, 16 October 2009, DOD CIO Memorandum.

EIA/IEEE J-016. Electronic Industries Association/Institute of Electrical and Electronics Engineers, Inc., *Standard for Information Technology, Software Lifecycle Processes Software Development Acquirer-Supplier Agreement*, EIA/IEEE Interim Standard J-STD-016-1995, September 1995.

FAR. Federal Acquisition Regulations (FAR), 2.101 (latest), https://www.acquisition.gov/far/current/html/Subpart%202_1.html (accessed 28 February 2013).

IEEE 1044. Institute of Electrical and Electronics Engineers, *IEEE Standard Classification for Software Anomalies*, IEEE Std 1044™-1993, 2 December 1993.

IEEE 1074. Institute of Electrical and Electronics Engineers, *IEEE Standard for Developing a Software Project Lifecycle Process*, IEEE Std 1074™-2006, 28 July 2006.

IEEE 1471. Institute of Electrical and Electronics Engineers, *IEEE Recommended Practice for Architecture Description of Software-Intensive Systems*, IEEE Std 1471-2000, September 2000.

IEEE 610.12. Institute of Electrical and Electronics Engineers, *IEEE Standard Glossary of Software Engineering Terminology*, IEEE Std 610.12-1990, September 1990.

ISO/IEC 15939. International Organization for Standardization/International Electrotechnical Commission (ISO/IEC), *Systems and Software Engineering – Measurement Process,* ISO/IEC 15939:2007, 1 August 2007.

ISO 9241-11. International Organization for Standards/International Electrotechnical Commission (ISO/IEC), Ergonomic requirements for office work with visual display terminals (VDTs) – Part 11, Guidance on usability, ISO 9241-11:1998, 15 March 1998.

McGarry 2001. McGarry, J., D. Card, C. Jones, B. Layman, E. Clark, J. Dean, and F. Hall, *Practical Software Measurement: Objective Information for Decision Makers*, October 2001, Addison Wesley.

Merriam-Webster. Merriam-Webster, *Collegiate Dictionary, Tenth Edition*, 1999.

Peresztegy 2009-1. Peresztegy, L. B., and C. E. O'Conner, *Technical Reviews and Audits for Systems, Equipment, and Computer Software, Volume 1*, Aerospace Report No. TOR-2007(8583)-6414, 13 January 2009, The Aerospace Corporation.

Peresztegy 2009-2. Peresztegy, L. B., and C. E. O'Conner, *Technical Reviews and Audits for Systems, Equipment, and Computer Software, Volume 2, Space Systems Supplement*, Aerospace Report No. TOR-2007(8583)-6414, 30 September 2009, The Aerospace Corporation.

Russia-U.S. 2010. EastWest Institute, *Russia-U.S. Bilateral on Cybersecurity – Critical Terminology Foundations*, April 2011.

Sather 2010. Sather, C. V., C. M. Rink, and J. M. Dixon, *Digital Application-Specific Integrated Circuit and Field-Programmable Gate Array Circuit Development Standard for Space Systems*, Aerospace Report No. TOR-2010(8591)-10, Revison A, December 2010, The Aerospace Corporation.

SEI 2010. CMMI Product Team, *CMMI for Development*, *Version 1.3,* Report No. CMU/SEI-2010-TR-033, November 2010, Software Engineering Institute, Carnegie Mellon University. Capability Maturity Model® and CMMI® are registered in the U. S. Patent and Trademark Office by Carnegie Mellon University.

Shaw 2013. Shaw, B. E., *Systems Engineering Requirements and Products*, Aerospace Report No. TR-2013-00001, 20 February 2013, The Aerospace Corporation. Also published as SMC-S-001.

SMC-S-012. Space and Missile Systems Center Standard, SMC-S-012, Software Development Standard. This is the same as this document.

TAI SPD. The Aerospace Institute, *Software Product Development Course*, 2012, The Aerospace Corporation (Aerospace internal).

Wikipedia. Wikipedia, *The Free Encyclopedia*, http://www.wikipedia.org (Accessed 28 Feb 2013). Definitions extracted in 2012 under the Creative Commons ShareAlike License found at http://creativecommons.org/licenses.

3. Definitions

3.1 Terms

The terms defined in this section appear in *italics* in the rest of the standard when they are not used as adjectives.

Acquirer. An organization that procures *products* for itself or another organization.

Agile development lifecycle model. A group of software development methods based on iterative and incremental development, where *requirements* and solutions evolve through collaboration between self-organizing, cross-functional teams. It promotes adaptive planning, evolutionary development and delivery, and a time-boxed iterative approach, and encourages rapid and flexible response to change. It is a conceptual framework that promotes foreseen interactions throughout the development cycle. Source: Adapted from (Wikipedia). See also *evolutionary*, *incremental*, *iterative*, *spiral*, and *waterfall development lifecycle models*.

Anomaly. See *discrepancy*.

Applicable. See Section 1.2.5.5.

Approval. Written notification by an authorized representative of the *acquirer* that a *developer's* plans, *requirements*, *designs*, or other aspects of the project appear to be sound and can be used as the basis for further work. Such approval does not shift responsibility from the *developer* to meet *contractual requirements*.

Architecture. The fundamental organization of the *system* or *software* embodied in its *components*, their relationships to each other, and to the environment, and the principles guiding its *design* and evolution. Source: Adapted from (IEEE 1471)

Associate developer. An organization that is neither *prime contractor, software team member,* nor *subcontractor* to the *developer*, but that has a development role on the same or related *system* or project.

Automatically generated code. *Source code* that is automatically generated by tools such as model-based software development tools, graphical user interface (GUI) builders, form builders, and computer-aided software engineering (CASE) tools.

Availability. Prior to the start of a mission, the probability that the *system* will be mission capable when a mission is needed. Availability accounts for system faults and the time it takes to restore the *system* to a mission capable state following failure. Source: (TAI SPD)

Bandwidth. A measure of available or consumed data communication resources. Examples of types of data communications resources include network, data bus, ground-ground link, ground-space link. Source: (Wikipedia)

Baseline. A *product* or a set of *work products* that has been formally reviewed and agreed on at a particular point in the item's lifecycle, which thereafter serves at the basis for further development, and which can be changed only through change control procedures. Source: Adapted from (SEI 2010) Note: A software baseline can be a single product or a set of consistent products for a particular *build* that can include, e.g., *requirements*, *architecture*, *design*, *source code* files and the associated executable code, build files, test plans, *test cases*, *test procedures*, test results, and *user documentation*. Source: Adapted from (SEI 2010)

Behavioral design. The design of how an overall *system* or a *software item* will behave, from a user's point of view, in meeting its *requirements*, ignoring the internal implementation of the *system* or the

software item. This design contrasts with architectural design, which identifies the internal *components* of the *system* or the *software item*, and with the detailed *design* of those *components*.

Bidirectional traceability. A two-way relationship between two products; for example, the relationship between a *requirement* and the *design* of a given *software component*, and the relationship between the *design* of the *software component* and the *requirements* it satisfies. Source: Adapted from (IEEE 610.12)

Build. A version of *software* that meets a specified subset of the *requirements* that the completed *software* will meet.
Note: The relationship of the terms "build" and "version" is up to the *developer*; for example, it can take several versions to reach a build, a build might be released in several parallel versions (such as to different sites), or the terms can be used as synonyms. Other terms that *developers* often use as synonyms include: block, cycle, drop, increment, iteration, and spiral. This standard uses the term "build" for all of these.

Categories of software. See Section 1.2.5.6.

Change request. A request for a change to *products*, *documents*, or *processes*. Change requests might result from a *discrepancy*, a new *requirement*, a changed *requirement*, or an improvement suggestion.

Characterization testing. Testing *software* or a *system* to explore and determine its behavioral, performance, and other characteristics. For example, the capabilities and capacity of an unfamiliar legacy or *COTS product* need to be analyzed to determine its suitability for use or whether it still behaves the same way after changes.

Checkout. The *process* after *software* has been installed at a *user site* or *maintenance* site to exercise the *software* to *demonstrate* that the *software* behaves as expected or required. Checkout procedures might use subsets of the *regression test suite*.

Child requirement. A *requirement* in a *child specification* that can be traced upward to one or more *requirements* in a *specification* in the *specification tree* immediately above that *child specification*. A child *requirement may* also be a *derived requirement*. See *parent requirement*.

Child specification. A *specification* in the *specification tree* that is immediately below another specification in the *specification tree*. See *parent specification*. Child specifications contain *child requirements*.

Commercial off-the-shelf (COTS) software. See *reusable software*.
Note: COTS *software* is sometimes called "commercial item" *software*. "Commercial item" is defined in the FAR 2.101. Source: (FAR)

Component. A constituent part. Source: (Merriam-Webster)

Computer database. See *database*.

Computer hardware. Devices capable of accepting and storing computer and sensor data, executing a systematic sequence of operations on computer data, or producing control outputs. Such devices can perform substantial interpretation, computation, communication, control, or other logical functions.

Computer program. A combination of computer instructions and data definitions that enable *computer hardware* to perform computational or control functions. The computer instructions and data definitions in a computer program can exist as *source code*, object code, or executable code. Source: (IEEE 610.12)

Computer software. See *software*.

Computer software configuration item (CSCI). See *software item*.

Computer software unit (CSU). See *software unit*.

Contract. The agreement between the *acquirer* and the *developer*. See Section 1.2.1.

Contract Data Requirements List (CDRL). See Section 1.2.1.

Contractual requirement. A mandatory statement in this standard or another portion of the *contract*.

Cyber-security. A property of *cyberspace* that is an ability to resist intentional and unintentional threats, respond, and recover. Source: (Russia-U.S.)

Cyberspace. An electronic medium through which information is created, transmitted, received, stored, processed, and deleted. Source: (Russia-U.S.)

Database. A collection of related data stored in one or more computerized files in a manner that can be accessed by *users* or *computer programs* via a database management system.

Database management system. An integrated set of *computer programs* that provides the capabilities needed to *establish*, modify, make available, and maintain the integrity of a *database*.

Data item description (DID). The format and content preparation instructions for a data *product* generated by the specific and discrete task *requirements* as delineated in the *contract*. Examples include DIDs for the Software Test Plan (STP), Software Test Report (STR), and Software User Manual (SUM) and templates for the Software Development Plan (SDP), Software Architecture Description (SAD), and Software Measurement Plan (SMP). See Section 6.2 for a list of DIDs and templates *applicable* to this standard.

Define. See Section 1.2.5.3.

Deliverable product. A *product* that is required by the *contract* to be delivered to the *acquirer* and other *acquirer*-designated recipients.

Demonstrate. To prove or make clear by evidence. Adapted from (Merriam Webster)
Note: Demonstrating always includes recording the information even if that is not explicitly stated. This definition of "demonstrate" is not to be confused with the verification method of "demonstration."

Dependability. The ability: a) to deliver service that can justifiably be trusted, and b) to avoid service failures that are more frequent and more severe than is acceptable. Dependability is an integrating concept that encompasses the following attributes:

1. readiness for correct service;
2. continuity of correct service;
3. absence of catastrophic consequences on the *user(s)* and the environment;
4. absence of improper *system* alterations; and
5. ability to undergo modifications and repairs. Source: (Avizienis 2004)

Derived requirement. A system or software *requirement* that results from architecture or design decisions or from the user's operational concepts and that is not directly traceable to one or more higher level *requirements*. A derived requirement may be either a *functional* or *nonfunctional requirement*.

Design. Those characteristics of a *system* or *software item* that are selected by the *developer* in response to the *requirements*. Some characteristics match the *requirements*; other characteristics are elaborations of *requirements*, such as definitions of all error messages in response to a *requirement* to display error messages; and others are implementation related, such as decisions about what *software units* and logic to use to satisfy the *requirements*.

Develop. See Section 1.2.5.3.

Developer. An organization that *develops* software *products* ("develops" includes new development, modification, integration, reuse, *reengineering*, *maintenance*, or any other activity that results in *products*). The term "developer" encompasses all *software team members*. See *software team member*.

Developer-internal software item integration testing. The last stage of software unit integration and *testing* where all of the *components* of the *software item* are integrated and tested. If the *software item* is developed in multiple *builds*, then the developer-internal *software item* integration testing occurs on a *build*-by-*build* basis.

Developer-internal system integration testing. The last stage of hardware-software integration and *testing* where all of the *components* of the *system* are integrated and tested. If the *system* is developed in multiple *builds*, then the developer-internal system integration testing occurs on a *build*-by-*build* basis.

Discrepancy. Any condition that deviates from expectations based on requirements *specifications*, architecture *documents*, design *documents*, user *documents*, plans, procedures, reports, standards, policy, etc., or from a *user's* or other *stakeholder's* sound engineering judgment or experiences. Discrepancies can be found during, but not limited to, the review, *test*, analysis, compilation, or use of *products* or *applicable documentation*. The term discrepancy is used throughout this standard where others might use the terms: anomaly, defect, error, fault, failure, incident, flaw, problem, gripe, glitch, or bug. Source: Adapted from the term "anomaly" in (IEEE 1044).

Discrepancy and change report (DCR). Documentation of *change requests*, *discrepancies*, and *test incidents*. Discrepancy and change reports are written for any potential change, *discrepancy*, or *test incident*, even if the final resolution is that no *discrepancy* exists, or if the *change request* is rejected. *Discrepancy* and change reports are sometimes called problem reports, change requests, trouble reports, *test incident* reports, issue reports, and other terms.

Document (as a verb). See Section 1.2.5.4.

Document (as a noun) or documentation. A collection of data, regardless of the medium on which it is recorded, that generally has permanence and can be read by humans or machines.

Duration testing. See *endurance testing and stability testing*. Contrast with *stress testing.*

End-to-end functional capability. A series of one or more *software* or *system* functions that:

1. satisfy a set of related *requirements* (or allocated portions of *requirements*);
2. exercise the *software* or *system* from inputs to the *software* or *system* through the *software* and hardware, interacting with *databases*, sensors, communications, and other software or system *components*, as *applicable*; and
3. result in outputs from the *software* to the *user,* another software or system *component*, or another *system*.

Note: The term "end-to-end functional capability," as used in this standard, applies only to *software unit* integration and testing (see Section 5.8.2), *software item qualification testing* (see Section 5.9.3), and software-hardware item integration and testing (see Section 5.10.2), and it does not apply to *system qualification testing*.

The scope of an end-to-end functional capability differs depending upon the entity under *test*. For *software unit* integration and testing, an end-to-end functional capability is defined by inputs to one or more *software units*, processing and data flows that cross unit boundaries, and outputs from one or more *software units*, that together satisfy the portion of *software* or software *interface requirements* allocated to the units under *test*. For *software item qualification testing*, an end-to-end functional capability is defined by inputs to the *software item*, processing by the *software item,* data flows through the *software item*, and outputs from the *software item* that together satisfy one or more

software item or software *interface requirements*. A similar interpretation applies to software-hardware integration testing. For *software-hardware item* integration and *testing*, an end-to-end functional capability is defined by inputs into a subset of the *software* or *hardware items* under *test*, processing and data flows through the *software* and *hardware items* under *test*, and outputs from a subset of the *software* or *hardware items* under test that together satisfy the portion of one or more *software*, *software interface*, hardware, or *subsystem requirements* allocated to the *software* and *hardware items* under test.

Endurance testing. *Testing* over prolonged execution time or elapsed time to determine whether longer-term execution shows functional, performance, or other problems.
Note: This *testing* often checks for clock overflows, buffer overflows, memory leaks, or other *discrepancies* that do not necessarily occur in shorter tests. Also known as *duration testing* or *stability testing*. Source: Adapted from (Cohen 2005). Contrast with *stress testing*.

Ensure. To make sure, certain, or secure by performing action(s). Source: Adapted from (Merriam-Webster).

Equivalence class. An input set ("class") in which all elements cause the same ("equivalent") execution path, regardless of which element from the class is chosen.

Establish. See Section 1.2.5.3.

Evaluation. The process of determining whether an item or activity meets specified criteria.

Evolutionary development lifecycle model. A *software development lifecycle model* in which requirements analysis and definition are done in each *build*. Each *build* can contain *architecture*, *design*, implementation, integration, and *testing* in an overlapping, iterative manner, resulting in evolutionary *requirements* and incremental completion of the overall software *product*. Each *build* is not necessarily delivered to the *acquirer*. See also *agile*, *incremental*, *iterative*, *spiral*, and *waterfall development lifecycle models*. Source: Adapted from (IEEE 610.12)

Expected results. The desired or required results specified in a *test case* or *test procedure* or both. Types of expected results include, but are not limited to, output data, responses from the software, status, colors, displays, warnings, alarms, events, or error messages. Expected results should include the units, range, accuracy, and precision of the output data, as *applicable*.

Extreme values. Values (of *test case* inputs) that are maximum values, minimum values, or the value zero for the data type of the *test case* inputs, whether or not those values are within the expected range.
Note: Extreme values might be discontinuous.

Firmware. The combination of a hardware device with computer instructions or computer data or both that reside as read-only *software* on the hardware device.

Functional requirement. A *requirement* that defines a specific behavior or function of the *system* or *software*. Contrast with *nonfunctional requirements* that specify criteria that can be used to judge the operation of a *system* rather than specific behaviors. In general, functional requirements define what a *system* is supposed to **do**, while *nonfunctional requirements* define how a *system* is supposed to **be**.

Hardware item. An aggregation of hardware that satisfies an end use function and is designated for *specification*, interfacing, *qualification testing*, configuration management, or other purposes.

High-fidelity simulator. A simulation that provides static and dynamic behavior representative of the object being modeled with, as a minimum, *nominal* and *off-nominal conditions*, stressing conditions, and erroneous conditions that could occur during a mission. Some of these conditions include, but are not limited to: correct format, incorrect format, error injection, correct timing, incorrect timing, normal volume of data, extensive volume of data, more data than the system can handle, higher data

rates than the system can handle, lost data blocks, extra data blocks, error data, changing data, fluctuating data, erroneous data, and any combination of the above.

Human factors engineering. The application of human behavior, abilities, limitations, and other characteristics to the design of *systems* for effective human use.

Identify. See Section 1.2.5.3.

Incremental development lifecycle model. A *software development lifecycle model* in which all software requirements analysis and definition occurs first, followed by a series of *builds* in which *architecture*, *design*, implementation, integration, and *testing* occur in an overlapping, iterative manner, resulting in incremental completion of the overall software *product*. Each *build* is not necessarily delivered to the *acquirer*. See also *agile*, *evolutionary*, *iterative*, *spiral*, and *waterfall development lifecycle models*. Source: Adapted from (IEEE 610.12)

Independent verification and validation (IV&V). Systematic *evaluation* of *products,* activities, or both by an agent that is not responsible for developing the *product* or performing the activity being evaluated. IV&V is not within the scope of this standard, but interfacing with IV&V agents is within the scope of this standard.

Information assurance. Measures that protect and defend information and information systems by ensuring their *availability*, integrity, authentication, confidentiality, and nonrepudiation. These measures include providing for restoration of information systems by incorporating protection, detection, and reaction capabilities. Information assurance ensures that the correct information is provided to the correct individuals at the correct time, in other words, that accurate information is shared only with those authorized to access it, and is available when it is needed. Source: (CNSSI 4009 2010)

Integral process. A *process* that supports the product-oriented development *processes* throughout the software lifecycle. Integral processes are performed concurrently with the product-oriented *processes* and are essential to their quality and completion. Examples of integral processes are the software peer review *process*, software measurement *process*, software quality assurance *process*, and software configuration management *process*.

Interface. In *software development*, a relationship among two or more entities (such as *software item* to *software item*, *software item* to *hardware item*, *software item* to user, *software unit* to *software unit*) in which the entities share, provide, or exchange data. An interface is not a *software item*, *software unit*, or other *system component*; it is a relationship among them.

Issue. A matter that is in dispute or is undecided. After investigation an issue could be resolved or could result in a *risk*, problem, or *discrepancy*.

Iterative development lifecycle model. A *software development lifecycle model*, such as *incremental*, *evolutionary*, or *spiral* with repeating and possibly overlapping development activities.
Note: Iterative development also includes agile development. See also *agile*, *evolutionary*, *incremental*, *spiral*, and *waterfall development lifecycle models*. Source: Adapted from (IEEE 610.12)

Joint review. A *process* or meeting involving representatives of both the *acquirer* and the *developer*, during which project status, *products*, and project *issues* are examined and discussed.

Key performance parameter (KPP). Those minimum attributes or characteristics considered most essential for an effective mission capability. Source: (DAU Glossary)

Maintain. See Section 1.2.5.3.

Maintainability.

1. The probability that the *system* can be retained in or returned to a mission capable state within a specified period of time when a failure occurs. See *software maintenance*.
2. The ease with which a software *system* or *component* can be modified to correct faults, improve performance or other attributes, or adapt to a changed environment. See *software maintenance*. Source: (IEEE 610.12)

Maintenance (of software). See *software maintenance*.

Maintenance organization. The organization that is responsible for modifying and otherwise sustaining the *software* and other software *products* and *documentation* after transition from the development organization (e.g., a separate organization within a *developer* company or a different organization).

May. See Section 1.2.4.2.

Nominal conditions. Those conditions that are within the range anticipated in the *requirements* and *design* (e.g., operator workloads, processor loads, memory utilizations, input and output data rates, timing and sequencing of input data, interface error rates, power, temperature, and related parameters affecting the computing run-time platform and environment).

Nominal values. Those values within the expected ranges, types, ordering, consistency, and completeness anticipated in the computer hardware and *software requirements* and *design*.

Nondeliverable product. A *product* that is not required by the *contract* to be delivered to the *acquirer* or other designated recipient.

Nonfunctional requirement. A system or software *requirement* that specifies criteria that can be used to judge the operation of the *system* or *software*, rather than specific behaviors. Contrast with *functional requirements* that define specific behavior or functions. In general, nonfunctional requirements define how a *system* is supposed to **be**, while *functional requirements* define what a *system* is supposed to **do**. Nonfunctional requirements are often called "qualities" of a system. Other terms for nonfunctional requirements are "constraints," "quality attributes," "quality goals," "quality of service requirements," and "nonbehavioral requirements." *Performance requirements*, including response times, throughput, and hard time deadlines, are considered nonfunctional requirements. Nonfunctional requirements can be divided into two main categories:

1. execution *requirements*, such as *security* and *usability*, which are observable at run time; and
2. evolution *requirements*, such as *testability*, *maintainability*, extensibility, and scalability, which are embodied in the static structure of the *software*. Source: Adapted from (Wikipedia)

Off-nominal conditions. Conditions that are outside of the range of *nominal conditions* (see *nominal conditions*).

Off-nominal tests. *Tests* of *off-nominal conditions* and *values*, the purpose of which is to determine whether the *software* or *system* behaves in a manner that enables it to remain in normal operations or recovery to normal operations.

Off-nominal values. Values that are outside the range of *nominal values* (see *nominal values*). For example, if the acceptable range of a temperature value is between 0° C and 70° C, inclusive, then temperature values less than 0° C and greater than 70° C are off-nominal.

Open source software (OSS). *Software* for which the human-readable *source code* is available for use, study, reuse, modification, enhancement, and redistribution by the *users* of that *software*. In other words, OSS is *software* for which the *source code* is "open." Source: (DOD-CIO 2009)

Operational hardware. Hardware in the operational system that is not part of the *target computer system*. Such hardware may have embedded *software* that is part of the *hardware item* but is not a separate *software item*. Changes to operational hardware include changes to its embedded *software*.

Parent requirement. A *requirement* in a *parent specification* that can be traced downward to one or more *requirements* in *specifications* in the *specification tree* immediately below that *parent specification*. See *child requirement.*

Parent specification. A *specification* in the *specification tree* that is immediately above one or more other *specifications* in the *specification tree*. See *child specification*. Parent specifications contain *parent requirements*.

Participate. See Section 1.2.5.2.

Performance requirement. See *nonfunctional requirement*.

Prime contractor. See Section 1.2.5.9.

Privacy protection. Absence of a weakness or failure that could lead to a breach of system privacy protection or of personally identifiable information. Source: (Avizienis 2004)

Process. A set of interrelated activities, which transform inputs into outputs, to achieve a given purpose, for example, the *software development process*. Source: (SEI 2010)

Product. Information created, modified, or incorporated by means of software or system development *processes*. Examples include plans, *requirements*, *architecture*, *design*, code, *databases*, test information, and manuals.

Prototype. A preliminary version of part of the hardware or *software* of a *system* that serves as a model for later stages or for the final, complete version of the *system*. Source: Adapted from (IEEE 610.12)

Prototyping. A hardware and *software development* technique in which a preliminary version of part of the hardware or *software* is developed early in the development *process* to permit user feedback, determine feasibility, or investigate timing or other *issues* in support of the development *process*. Source: Adapted from (IEEE 610.12)

Qualification testing. *Testing* performed to verify that a *system* or *software item* meets its specified *requirements*.

Quality attribute. See *nonfunctional requirement*.

Record (as a verb). See Section 1.2.5.4.

Redline. To mark up a *document* to show changes, either with a pen (usually a red one), or electronically using a track changes feature. The term "redline" is also used for the resulting changes.

Reengineering. The *process* of examining and altering an existing *system* to reconstitute it in a new form. It could include reverse engineering (analyzing a *system* and producing a representation at a higher level of abstraction, such as *design* from *source code*), restructuring (transforming a *system* from one representation to another at the same level of abstraction), redocumentation (analyzing a *system* and producing *user* or support *documentation*), forward engineering (using *products* derived from an existing *system*, together with new *requirements*, to produce a new *system*), retargeting (transforming a *system* to install it on a different *target computer system*), and translation (transforming *source code* from one language to another or from one version of a language to another).

Regression testing. Selective retesting of a *system* or *component* to determine whether modifications to the *system* or its environment (e.g., operating system, *software*, or hardware) have caused unintended effects and to determine whether the *system* or *component* still complies with its specified *requirements*. Source: Adapted from (IEEE 610.12)

Regression test suite. A set of *test cases*, *test procedures*, test drivers, test data, test *databases*, and instructions for preparing the test environment that is used to determine whether any changes adversely impact the functioning or performance of the *software* or *system* or adversely impact the previously verified *requirements*. See *regression testing*.

Reliability. The probability that the *system* will be able to complete the mission without failure, given that the *system* was available at the start of the mission.

Representative set. A set of values selected from an *equivalence class* that is representative of the distribution of values or conditions. The size of the set, i.e., the quantity of the values, within each *equivalence class* is dependent on the *software item* or *system* in question and the level of confidence needed for successful execution during *nominal* and *off-nominal conditions*.

Requirement.

1. A mandatory characteristic of a *system* or *software item*.
2. A mandatory statement in this standard or another portion of the *contract*.

Note: Software *requirements* also include software interface *requirements*.

Reusable software. *Software* developed for one use but having other uses, or developed specifically to be usable on multiple projects or in multiple roles on one project. Each use could include all or part of the software and could involve its modification. Examples of reusable software include, but are not limited to:

1. pre-existing *developer software*, including product-line *software*;
2. *software* in reuse libraries;
3. *acquirer*-furnished *software*;
4. open source *software* (OSS); and
5. *commercial off-the-shelf (COTS) software*.

Note: Software *documentation products* (for example, *requirements*, *architectures*, *design*, *test cases*) can also be reused, but they are not included in this definition of reusable software.

Risk. The potential for a negative future reality. Source: (DOD DAU 2001), Ch. 15

Safety. Absence of conditions that can cause a hazardous system state, i.e., one that could result in unintended death, injury, occupational illness, damage to or loss of property, environmental harm. Source: Adapted from (Avizienis 2004)

Security.

1. Security ensures that a system can deliver the correct information to the correct individuals at the correct time. This includes the concurrent existence of:
   a. *availability* for authorized actions only;
   b. confidentiality, i.e., the absence of unauthorized disclosure of information; and
   c. integrity, i.e., absence of unauthorized system alterations. Source: (Avizienis 2004)
2. A condition that results from the establishment and maintenance of protective measures that enable an enterprise to perform its mission or critical functions despite *risks* posed by threats to its use of information systems. Protective measures *may* involve a combination of deterrence, avoidance, prevention, detection, recovery, and correction that *should* form part of the enterprise's risk management approach. Source: (CNSSI 4009 2010)

Note: For computer systems, security includes *information assurance* and *cyber-security*.

Shall. See Section 1.2.4.2.

Should. See Section 1.2.4.2.

Software. *Computer programs*, procedures, and data pertaining to the operation of a computer system. Data includes, for example, information in *databases*, rule bases, and configuration data. Procedures

include, for example, interpreted scripts, command macros, and stored commands. Source: Adapted from (IEEE 610.12)
Note: Although some definitions of software include *documentation*, this standard limits the definition to *computer programs*, procedures, and data.

Software development. A set of activities that results in software *products*. Software development includes new development, modification, reuse, *reengineering*, *maintenance*, and any other activities that result in software *products*.

Software development file (SDF). A repository for material pertinent to the development of a particular body of *software*. Contents typically include (either directly or by reference) the development products themselves as well as considerations, rationale, and constraints related to *requirements* analysis, *architecture*, *design*, and implementation; test information, including *test cases* and test results; *discrepancy and change reports*; technical reports; notes; and schedule and status information. Source: Adapted from (IEEE 610.12)
Note: The body of *software* may be at different levels of integration (e.g., *software unit*, collection of related *software units*, software *build*, *software item*).

Software development library (SDL). A controlled collection of *software*, *documentation*, other intermediate and final software *products*, and associated tools and procedures used to facilitate the orderly development and subsequent *maintenance* of *software*.

Software development lifecycle model. A project management framework:

1. containing the activities involved in the development, operation, and *maintenance* of the *software*; and
2. spanning the life of the *software* from the definition of its *requirements* to the termination of its use.

See *agile*, *evolutionary*, *incremental*, *iterative*, *spiral*, and *waterfall development lifecycle models*.
Source: Adapted from (IEEE 610.12) See (IEEE 1074) for more information.

Software development process. An organized set of activities performed to translate user needs into software *products*.

Software engineering. In general usage, a synonym for *software development*. As used in this standard, a subset of *software development* consisting of all activities except integration and *qualification testing*. The standard makes this distinction for the sole purpose of giving separate names to the *software engineering environment* and *software integration and qualification test environment*.

Software engineering environment. The facilities, hardware, *software*, *firmware*, procedures, and *documentation* needed to perform *software engineering*, including, but not limited to, tools to develop and analyze *requirements*, architect, *design*, *develop*, control, generate, verify, and load the *software*. Elements include, but are not limited to, computer-aided software engineering (CASE) tools, requirements management tools, architecture modeling tools, compilers, assemblers, linkers, loaders, code analyzers, path and coverage analyzers, operating systems, debuggers, simulators, emulators, configuration management tools, *discrepancy* and change reporting tools, measurement tools, unit *test case* generators and other unit test tools, *documentation* tools, and database management systems.
Note: There may be multiple software engineering environments for various team members and sites.

Software integration and qualification test environment. The facilities, hardware, *software*, *firmware*, procedures, and *documentation* needed to perform integration, *qualification* and possibly other *testing* of *software*. Elements include, but are not limited to, hardware, test *software*, test drivers, automated test equipment, test beds, instrumentation, *test case* generators, automated test result checking tools, other test analysis tools, simulators, emulators, and *databases* and *database* values. Elements used in the *software engineering environment* can also be used in the software integration and *qualification*

test environment. Note: There may be multiple integration and qualification testing environments for different team members, levels of integration and testing, and sites.

Software item. An aggregation of *software* that satisfies an end use function and is designated for *specification*, interfacing, *qualification testing*, configuration management, and other purposes. Software items are selected based on tradeoffs among software function, size, host or *target computer systems*, *developer*, support strategies, plans for reuse, criticality, interface considerations, the need to be separately documented and controlled, and other factors. A software item is composed of one or more *software units*. A software item is sometimes called a computer software configuration item (CSCI). Source: Adapted from (EIA/IEEE J-016)

Software item qualification test environment. The facilities, hardware, *software*, *firmware*, procedures, and *documentation* needed to perform *qualification testing* of the *software*. This is usually a subset of the *software integration and qualification test environment*.

Software maintenance. The set of activities that takes place to ensure that *software* installed for operational use continues to perform as intended and fulfill its intended role in system operation. Software maintenance includes software corrections and improvements, user assistance, and related activities. Source: Adapted from (EIA/IEEE J-016)

Software quality. The ability of *software* to satisfy its specified *requirements* and expectations.

Software support. See *software maintenance*.

Software-only system. A *system* consisting solely of *software* and possibly the computer equipment on which the *software* operates.

Software team member. The *prime contractor* or any internal or external organization that *develops*, *tests*, integrates, or supports software-related work being performed for the *contract* and that has a formal or informal agreement with the *prime contractor* or any other team member. These organizations include, but are not limited to, intra-corporation organizations, in-house service providers, *developers*, fabrication and manufacturing organizations, laboratories, joint venture partners, teaming partners, subsidiaries, interdivisional transfer, and corporations that have a legal *contract* with the *prime contractor* or other team member. Examples of an agreement include a *contract*, work authorization, memorandum of agreement, or oral agreement. This standard includes all software team members under the term *developer*.

Software transition. The set of activities that enables responsibility for *software* to pass from one organization to another.

Software unit. An element in the *design* of a *software item,* for example, a major subdivision of a *software item*, a *component* of that subdivision, a class, object, module, function, routine, or *database*. Software units might occur at different levels of a hierarchy and might consist of other software units. Software units in the *design* might or might not have a one-to-one relationship with the code and data entities (e.g., routines, procedures, *databases*, data files) that implement them or with the computer files containing those entities. A software unit is sometimes called a computer software unit (CSU).

Source code. Computer instructions and data definitions expressed in a form suitable for input to an assembler, compiler, or other translator. Source: (IEEE 610.12)

Specification. A description of the verifiable technical *requirements* and design constraints for hardware and *computer software*, materials, and processes along with the *verification method* for determining whether each *requirement* is met. Source: (Shaw 2013)

Specification tree. The hierarchy of *system components* for which *requirements* are defined. This hierarchy of *system components* is usually depicted as a tree diagram.

Spiral development lifecycle model. A *software development lifecycle model* in which the selection of constituent activities, typically *requirements* analysis and definition, *architecture*, *design*, *prototyping*, coding, integration, and *testing*, are performed for each spiral based on the information that is needed to reduce *risk*. After each spiral, the new information and the remaining *risks* help the stakeholders select the activities for the next spiral. These spirals continue until the *software* is complete. See also *agile*, *evolutionary*, *incremental*, *iterative*, and *waterfall development lifecycle models*. Source: Adapted from (IEEE 610.12)

Stability testing. See *endurance testing*.

Stakeholder. A group or individual that is affected by or is in some way accountable for the outcome of a product. Adapted from (SEI 2010)

Statement of Work (SOW). See Section 1.2.1.

Stress testing. Testing using worst-case scenarios (e.g., extreme workloads, high frequency of inputs and events, large number of *users*, simulated failed hardware, missing or malfunctioning interfaces, tight timelines) to determine whether these aspects show functional, performance, or other problems. Contrast with *duration testing*, *endurance testing*, and *stability testing*.

Subcontractor. See Section 1.2.5.10.

Subsystem. See Section 1.2.5.1.

Supplier. As used in this standard, a *software team member* that provides *reusable software products*. This includes vendors of *COTS products*.

Support (of software). See *software maintenance*.

Supportability. The degree to which *system* design characteristics and planned logistics resources, including *software*, meet mission readiness and operational utilization requirements before the mission begins.

System. See Section 1.2.5.1.

Target computer system (TCS). The *computer hardware*, including all computer-related hardware such as processors, memory, storage, networks, and data interfaces, on which the operational *software* will reside and execute. The TCS used for *software item qualification testing* (SIQT) (and possibly for software-software and software-hardware integration testing) is an exact duplicate of the actual TCS that will be used in mission operations. The TCS contains the exact same model(s) of the processor(s) with the exact same instruction set(s) and timing as is used in mission operations. It *should* be from the same batch of processors.
Note 1: For space systems during *testing*, the TCS is called the "flight-like target computer system." The only difference is that it is not the TCS that goes through all of the environmental tests.
Note 2: For some ground systems during *testing,* the TCS is called the "site-identical computer system" or the "site-identical target computer system."
Note 3: For some ground systems, representative networks and a subset of target computer systems *may* be used for a case where the final deployed networks and configurations are not accessible to the test team. In this case, one or more procedures from the qualification test suite need to be re-executed at the user site for:
1) performance requirements,
2) concurrent access by users across the network, and
3) worst cases.

Technical performance measure (TPM). A measurement that indicates progress toward meeting critical system characteristics (technical parameters) that are specified in *requirements* or constrained by system *design*. Technical parameters that are tracked with TPMs have clearly identifiable and

measurable target and threshold values. Examples of software technical parameters, which can be tracked using TPMs, are computer system resource margins (e.g., central processing unit (CPU), input and output (I/O) volume or rates, memory margins) and response times.

Test. The terms "test" and "testing," as used in this standard, refer to the activities of verifying that the implementation meets the *design* (unit and integration testing) and verifying that the *requirements* are satisfied (*qualification testing*). These terms are distinct from the *verification method* "Test," which is only one of the four standard methods used for *verification*, i.e., Inspection (I), Analysis (A), Demonstration (D), and Test (T). See *verification method*.

Testability. The degree to which:

1. a *requirement* is stated in terms that permit establishment of test criteria and performance of *tests* to determine whether those criteria have been met, or
2. a *system* or *component* facilitates the establishment of *test* criteria and the performance of *tests* to determine whether those criteria have been met. Source: Adapted from (IEEE 610.12)

Test activity suspension. A temporary interruption of *testing* activities from which recovery can be made without corrections to *software*, hardware, *test procedures*, test environment, or configuration. Criteria for suspension could include, e.g., *test interruptions* and *test incidents*.

Test activity termination. A halt to *testing* activities until a future date after necessary corrections to *software*, hardware, *test procedure*, test environment, or configuration have been made and checked out. Test activity termination usually requires a test dry run before resumption of *test* activities. Criteria for termination could include, e.g., 10 percent of the nominal cases fail.

Test case. A set of items for a test. Each test case consists of the *verification method*, *requirements* to be verified, inputs, prerequisite conditions, *expected results*, and criteria for evaluating results.

Test incident. Any event occurring during the execution of a software *test* that requires investigation. Source: Adapted from (IEEE 610.12)

Test interruption. Any interruption of *testing*. Examples of causes include: computer crash, incorrect configuration discovered, equipment or hardware problem or failure, simulator problem, power failure, biological break, water pipe break, exercise, evacuation (e.g., fire alarm, drill, tornado, hurricane, earthquake).

Test procedure. The collection of execution and analysis steps, including *expected results*, that are to be performed in order to obtain the test results needed to verify the *requirements*. Each *test case* has one or more associated test procedures.

Transition (of software). See *software transition*.

Turnover. The event when operations officially starts using the system or a new version of the system.

Usability. The extent to which a *product* can be used by specified *users* to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use. Usability is a *nonfunctional requirement*. Source: Adapted from (ISO 9241-11)

User. See Section 1.2.5.7.

User site. See Section 1.2.5.8.

Validation. Confirmation that the *product* or service, as provided (or as it will be provided), will fulfill its intended use. Validation ensures that "you built the right thing." (See *verification*.) Source: (SEI 2010)

Verification. Confirmation that *work products* and *products* properly reflect the *requirements* specified for them. Verification ensures that "you built it right." (See *validation*.) Source: Adapted from (SEI 2010)

Verification method. One of four techniques used to fully or partially verify a *requirement*: Inspection (I), Analysis (A), Demonstration (D), and Test (T). These techniques are also called "qualification methods." These four techniques are defined as follows:

1. Inspection. A method used to determine characteristics by inspecting engineering *documentation* produced during product development, including both hardware and software *documentation*, or by inspection of the *product* itself to verify conformance with specified *requirements*. Inspection generally is nondestructive and consists of visual inspections or simple measurements without the use of precision measurement equipment.
2. Analysis. A method used to verify *requirements* by determining qualitative and quantitative properties and performance by studying and examining engineering drawings, software and hardware flow diagrams, software and hardware *specifications*, and other hardware and software *documentation* (e.g., *COTS* vendor *documentation*), or by performing modeling, simulation, or calculations, or any combination, and analyzing the results. Similarity analysis is used in lieu of *tests* or *demonstrations* when it can be shown that an item is similar to or identical in *design* to another item that has been certified previously to equivalent or more stringent criteria.
3. Demonstration. A method used to verify *requirements* by exercising or operating the *system* or a part of the *system* in which instrumentation or special test equipment is not required beyond that inherently provided in the *system* being verified. In the demonstration method, sufficient data for *requirements verification* can be obtained by observing functional operation of the *system* or a part of the *system*. When this verification method generates data that are recorded by inherent instrumentation, inherent test equipment, or operational procedures, any analysis that must be performed using the data collected during the demonstration is an integral part of this method and should not be confused with the analysis method of *verification* described above.
4. Test. A method used to verify *requirements* by exercising or operating the *system* or a part of the *system* using instrumentation (hardware or *software* or both) or special test equipment that is not an integral part of the *system* being verified. The test method by its nature generates data, which are recorded by the instrumentation, test equipment, or procedures. Analysis or review is performed on the data derived from the testing. This analysis, as described here, is an integral part of this method and should not be confused with the *analysis* method of *verification* described above. Source: (Adams 2002)

Waterfall development lifecycle model. A *software development lifecycle model* in which the constituent activities, typically a concept phase, *requirements* phase, *architecture* phase, *design* phase, implementation phase, *test* phase, and installation and checkout phase, are performed in that order, possibly with overlap but with little or no iteration. See also *agile*, *evolutionary*, *incremental*, *iterative*, and *spiral development lifecycle models*. Source: Adapted from (IEEE 610.12)

Work product. Part or all of a *product* produced by means of the activities in this standard. A work product can be a *component* of a *product* but is not necessarily a *deliverable product*.

4. General Requirements

1. This standard **shall** apply to all *software team members*.
   Note: The *prime contractor* is considered a *software team member* (see Section 3).
2. This standard **shall** apply to all *categories of software* defined in Section 1.2.5.6 that are within the scope of the *contract*.
   Note: This standard applies to s*oftware* included in the *categories of software* whether or not the *software* is identified as a *software item*.
3. This standard **shall** apply to *software* installed in *firmware* devices.
   Note 1: This standard does not apply to the hardware element of *firmware*.
   Note 2: For more detailed requirements for Application-Specific Integrated Circuits (ASICs) and Field-Programmable Gate Arrays (FPGAs), see (Sather 2010) and (Dixon 2006).

4.1 Software Development Process

The framework used to organize the major software activities is called the *software development lifecycle model*.

1. The *developer* **shall** select *software development lifecycle model(s)* appropriate to the *software* being developed.
   Note: A software project can have more than one *software development lifecycle model* in use for the different *categories of software* being developed. (See Section 3.1 for definitions of *agile, evolutionary, incremental, iterative, spiral,* and *waterfall lifecycle models*.)
2. The *developer* **shall** *record* the selected *software development lifecycle model(s)* in the Software Development Plan (SDP) template in Appendix H.1 Software Development Plan Template.
   Note: See Section 6.2 for the SDP template identifier.
3. The *developer* **shall** provide in the SDP a description of each *software development lifecycle model* that will be used on the project.
4. The *developer* **shall** define in the SDP the following for each *software development lifecycle model* to be used:
   a. the portion of the system development lifecycle where it will be used,
   b. under which circumstances it will be used, and
   c. for which *software items* it will be used.
5. The *developer* **shall** *establish* a *software development process* consistent with *contract requirements*.
6. The *software development process* **shall** include the following major activities and *integral processes*:
   a. Project Planning and Oversight (Section 5.1)
   b. Establishing a *Software Development* Environment (Section 5.2)
   c. System *Requirements* Analysis (Section 5.3)
   d. System Architectural *Design* (Section 5.4)
   e. Software *Requirements* Analysis (Section 5.5)
   f. Software *Architecture* and *Design* (Section 5.6)
   g. Software Implementation and Unit *Testing* (Section 5.7)
   h. Unit Integration and *Testing* (Section 5.8)
   i. *Software Item Qualification Testing* (Section 5.9)
   j. Software-Hardware Item Integration and *Testing* (Section 5.10)
   k. *System Qualification Testing* (Section 5.11)
   l. Preparing for *Software Transition* to Operations (Section 5.12)
   m. Preparing for *Software Transition* to *Maintenance* (Section 5.13)

n. Integral *Processes*:
   (1) Software Configuration Management (Section 5.14)
   (2) Software Peer Reviews and Product *Evaluations* (Section 5.15)
   (3) Software Quality Assurance (Section 5.16)
   (4) Corrective Action (Section 5.17)
   (5) Joint Technical and Management Reviews (Section 5.18)
   (6) Software Risk Management (Section 5.19)
   (7) Software Measurement (Section 5.20)
   (8) *Security* and Privacy (Section 5.21)
   (9) *Software Team Member* Management (Section 5.22)
   (10) Interface with Software *IV&V* Agents (Section 5.23)
   (11) Coordination with *Associate Developers* (Section 5.24)
   (12) Improvement of Project Processes (Section 5.25)

Note: These major activities *may* overlap, *may* be applied iteratively, *may* be applied differently to various elements of *software*, and need not be performed in the order listed above.

7. The *developer's software development processes* **shall** be described in the Software Development Plan (SDP).
   Note: The sections specified in parentheses after each activity and integral process in #6 above are the SDP sections where the *processes* are to be described. See Section 6.2 for the SDP template identifier.

4.2 General Requirements for Software Development

This section specifies the general developer *requirements* for carrying out the detailed *requirements* in Section 5 of this standard. See Appendix H.1 for more detailed *requirements*.

4.2.1 Software Development Methods

1. The *developer* **shall** use systematic, *documented* methods for all *software development* activities.
2. These systematic software development methods **shall** be specified in the SDP.
   Note: See Appendix H.1 SDP Template contents § 4.2.1 for more detailed information.

4.2.2 Standards for Software Products

1. The *developer* **shall** *develop* standards for representing *requirements*, *architecture*, *design*, code, *test cases*, *test procedures*, and test results.
2. These product representation standards **shall** be specified in the SDP.
3. The *developer* **shall** apply the standards specified in the SDP for representing *requirements*, *architecture*, *design*, code, *test cases*, *test procedures*, and test results.
   Note: See Appendix H.1 SDP Template contents § 4.2.2 for more detailed information.

4.2.3 Traceability[2]

Traceability provides a relationship between the contents of two related *products*, such as the relationship from each software *requirement* to the software design *component(s)* that satisfy the *requirement*. *Bidirectional traceability* provides a two-way relationship between the contents of two related *products*. An example of such a two-way relationship is the traceability from each software *requirement* to the software design *component*(*s*) that satisfy the *requirement* and the traceability from each design *component* to the software *requirement(s)* satisfied by the design *component*.

The intent of the *bidirectional traceability requirements* in this section is to trace both upward and downward to:

1. *demonstrate* that all *requirements* are allocated to *components*, implemented, and tested,

[2] This subsection is based on information from Section 4.2.3 of (EIA/IEEE J-016).

2. *demonstrate* that no extra *requirements* are implemented,
3. provide information on the impacts of proposed changes,
4. provide information on the impacts of discovered problems, and
5. provide information for *software maintenance*.

Bidirectional traceability applies to all levels of *requirements* within the *system,* including the *system* level, the *subsystem* levels, and the *software item* level. At each level of the *specification tree*, the *requirements* in each *parent system* or *subsystem specification* are traced down to the *applicable requirements* in the child *subsystem*, *software item*, or *hardware item specifications* immediately beneath their parents in the *specification tree*, and each requirement in a *child specification* is traced back up to the *applicable requirements* in the *parent specification*. When *requirements* are derived in whole or in part from *design* decisions, those *requirements* are *bidirectionally* traced to the *documented design* decisions.

The term "*subsystem*" as defined in Section 1.2.5.1 is used for any number of levels between the system level and the software level. When this standard uses the word "*subsystem*," it indicates one of several possible levels between the system and software levels.

As an example, consider a *system* that has a *system specification* and its *design* has three *subsystems.* The system *requirements* are allocated to the *child subsystems*, and the system *requirements* are traced to the *child subsystem requirements*. In turn, the *child subsystem requirements* are traced back to the *parent system requirements*. This *process* is repeated for every level in the *specification tree* for the *system*. Eventually, at the lowest level of the *subsystems* in the *specification tree*, the *subsystem requirements* are allocated to *software items*, *hardware items*, and manual operations. The software *requirements* for each *software item* are traced back up to its *parent subsystem requirements*, and the *parent subsystem requirements* are traced down to the software *requirements*. The *parent subsystem* for a *software item* is the *subsystem* immediately above the *software item* in the *specification tree*.

The same philosophy of *bidirectional traceability* applies to tracing the allocation of *requirements* up and down throughout the lifecycle sequence of software *products*. Thus, there is *bidirectional traceability* between software *requirements* and:

1. the architecture components that implement the requirements;
2. the units in the software design that implement the requirements;
3. test cases for software unit testing;
4. test cases for unit integration testing;
5. test cases for software-hardware integration testing;
6. tests in the Software Test Plan (STP);
7. test cases in the Software Test Description (STD); and
8. test procedure steps in the STD.

Bidirectional traceability also applies between other software *products*. For example, there is *bidirectional traceability* between:

1. software *architecture components* and the units in the software *design*, and
2. *software units* and the *source code* files that implement the *software units.*

Bidirectional traceability thus ensures that if a change is proposed to a system, subsystem, or software *requirement*, the impact of that change can more easily be determined. If a problem or *discrepancy* is detected in *software*, the *bidirectional traceability* can be used to find the related upstream *products* so that they can be analyzed to determine the source of the error or ambiguity. The *bidirectional traceability* can then be used to determine other downstream *products* to which the error or ambiguity could have propagated.

For efficiently producing correct *bidirectional traceability* information and updating that information across the lifecycle as new *products* are developed and changes are made, the *developer* is strongly

encouraged to use one or more tools for *recording* and managing the *bidirectional traceability* information. The *products* whose *DID*s require traceability information can reference the traceability information in these tools.

1. The *bidirectional traceability* information specified in this section, Section 4.2.3 and its subparagraphs, **shall** be *recorded* as specified in the SDP.

4.2.3.1 Bidirectional Traceability for Requirements

1. The *developer* **shall** *participate* in *defining* and *recording bidirectional traceability* between all levels of *system* and *subsystem requirements*, including *functional* and *nonfunctional requirements*, as *applicable*, including all items in the traceability section of the System/Subsystem Specification (SSS) *DID*.
   Note: This *requirement* applies to all levels of *requirements* in the *specification tree* above the level of software *requirements*.
2. The *developer* **shall** *participate* in *defining* and *recording bidirectional traceability* between the *system* or *subsystem components* and *system* or *subsystem requirements,* including *functional* and *nonfunctional requirements,* that are allocated to those *system* or *subsystem components*, including all items in the traceability section of the System/Subsystem Design Description (SSDD) *DID*.
3. The *developer* **shall** *define* and *record bidirectional traceability* between each software *requirement* and the *system* or *subsystem requirements* that the software *requirement* addresses, including all items in the traceability section of the Software Requirements Specification (SRS) *DID*.
4. When *requirements* are derived in whole or in part from architecture or design decisions or user's operational concepts, then those *requirements* **shall** be *bidirectionally traced* to the *documentation* of those decisions and operational concepts.
5. The *developer* **shall** *define* and *record bidirectional traceability* between each *software interface requirement* and the *system* or *subsystem requirements* that the *software interface requirement* addresses, including all items in the traceability section of the Interface Requirements Specification (IRS) *DID*.

4.2.3.2 Bidirectional Traceability for Architecture and Design

1. The *developer* **shall** *define* and *record bidirectional traceability* between the following pairs, including all items in the traceability sections of the Software Architecture Description (SAD) template:
   a. software *architecture components* and the *software requirements* and *software interface requirements* allocated to the *architecture components*; and
   b. software use cases, or equivalent, and the *software requirements* and *software interface requirements* allocated to the use cases, or equivalent.

   Note: See Section 6.2 for the SAD template identifier.
2. The *developer* **shall** *define* and *record bidirectional traceability* between the following pairs, including all items in the traceability section of the Software Design Description (SDD) *DID*.
   a. each *software* unit and each software requirement that is allocated to the software unit, and
   b. each *software* unit and each interface requirement that is allocated to the software unit.

   Note: The software requirements are documented in the SRS and the software interface requirements are documented in the IRS
3. The *developer* **shall** *define* and *record bidirectional traceability* between *software interfaces* described in the Interface Design Description (IDD) and the *system*, *subsystem*, software, or *software interface requirements* allocated to that *interface*, including all items in the traceability section of the IDD *DID*.

Note: For *systems* with multiple levels of *subsystem requirements*, an *interface* could be defined at any level of the *specification tree*. *Requirements* for an *interface* could be specified in *system* or *subsystem specifications*, as *applicable*, or could be specified in *software requirements, software interface requirements specifications*, or *interface* control *documents* (ICDs).

4. The *developer* **shall** *define* and *record bidirectional traceability*, including all items in the traceability section of the Database Design Description (DBDD) *DID* between the:
   a. *databases* described in the DBDD and the *system*, *subsystem, software,* and *software interface requirements* allocated to those *databases;* and
   b. *software units* described in the DBDD and the *system*, *subsystem,* software, and *software interface requirements* allocated to those *software units*.

   Note: For *systems* with multiple levels of *system requirements*, a *database* could be defined at any level of the *specification tree*. *Requirements* for a *database* could be specified in *system* or *subsystem specifications*, as *applicable*, or could be specified in *software requirements specifications, including software interface requirements*.

4.2.3.3 Bidirectional Traceability for Testing

1. The *developer* **shall** *define* and *record* the *bidirectional traceability* between each *software unit test case* and the *software requirements* and *software interface requirements* addressed by the *software unit test case.*
2. The *developer* **shall** *define* and *record* the *bidirectional traceability* between each unit integration and testing (I&T) *test case* and the *software requirements* and *software interface requirements* addressed by the unit I&T *test case*.
3. The *developer* **shall** *define* and *record* the *bidirectional traceability*, including all items in the traceability section of the Software Test Plan (STP) *DID* between the *tests* defined in the STP and the *software requirements* and *software interface requirements* addressed by those *tests.*
4. For *software-only systems*, the *developer* **shall** *define* and *record* the *bidirectional traceability* between the *tests* defined in the STP and the *system* or *subsystem requirements* addressed by those *tests*, including all items in the traceability section of the STP *DID*.
5. For each *test case* defined in the Software Test Description (STD), the *developer* **shall** *define* and *record* the *bidirectional traceability*, including all items in the traceability section of the STD *DID* concerning *test cases* between the *test case* defined in the STD and the software *requirements* and software *interface requirements* addressed by the *test case*.
6. For *software-only systems*, for each *test case* defined in the STD, the *developer* **shall** *define* and *record* the *bidirectional traceability* between the *test case* defined in the STD and the *system* or *subsystem requirements* addressed by the *test case*, including all items in the traceability section of the STD *DID* concerning *test cases*.
7. For each *test case* defined in the STD that addresses multiple *requirements*, the *developer* **shall** *define* and *record* the *bidirectional traceability* between the *requirements* addressed by that *test case* and the steps in the *test procedure(s)* for the *test case* where the *requirements* are addressed, including all items in the traceability section of the STD *DID* concerning *test procedures*.
8. The *developer* **shall** *participate* in *defining* and *recording* the *bidirectional traceability* between each software-hardware I&T *test case* and the *requirements* addressed by that *test case*.
9. For *software-only systems*, for each software-hardware I&T *test case* that addresses multiple *requirements*, the *developer* **shall** *define* and *record* the *bidirectional traceability* between the *requirements* addressed by that *test case* and the steps in the *test procedure(s)* for the *test case* where the *requirements* are addressed.

   Note: In software-only systems, the hardware is provided to the *contract*, and the *developer* is not responsible for developing the hardware. The software-only system must interface with, or possibly control, the hardware.

10. For *software-only systems*, the *developer* **shall** *define* and *record* the *bidirectional traceability* between the *system qualification test cases* and the *requirements* addressed by those *test cases*.
11. For *software-only systems*, for each *system qualification test case* that addresses multiple *requirements*, the *developer* **shall** *participate* in *defining* and *recording* the *bidirectional traceability* between the *requirements* addressed by that *test case* and the steps in the *test procedure* for the *test case* where the *requirements* are addressed.

4.2.3.4 Bidirectional Traceability for Delivery to Operations and Maintenance

1. The *developer* **shall** *define* and *record* the *bidirectional traceability,* including all items in the traceability section of the Software Product Specification (SPS) *DID*:
   a. between each *software unit* and the *source code* files that implement that *software unit*, and
   b. between the *computer hardware* resource utilization measurements and the software item *requirements* concerning them.

   Note 1: The *source code* files could contain newly developed code, unmodified reusable code, and modified reusable code. Here, reusable code encompasses any type of reuse *source code* (e.g., from legacy systems and *open source software*).

   Note 2: The *developer* is encouraged to *define* and *record* the *bidirectional traceability* between these items during implementation and integration and *testing* rather than delaying until the SPS is prepared.

4.2.4 Reusable Software Products

1. The *developer* **shall** identify *reusable software products* for use in fulfilling the *requirements* of the *contract*.
2. The scope of the *reusable software product* search **shall** be specified in the SDP.
3. The *developer* **shall** evaluate the identified *reusable software products* for use in fulfilling the *requirements* of the *contract*.
4. The criteria to be used for *evaluation* of the *reusable software product* **shall** be as specified in the SDP.
5. The *developer* **shall** use, as a minimum, the *evaluation* criteria in Appendix B for selecting *reusable software products*.

   Note: The *evaluation* criteria *may* be weighted differently for different *categories of software* and for different critical *requirements*.
6. The selected *reusable software products* **shall** meet the data rights *requirements* in the *contract*.
7. If *COTS* or any other *reusable software* has undesired functionality that has not been removed, the *developer* **shall** *demonstrate* that this functionality does not impact the *software* or *system*.

Note 1: The *developer* can be required by the *contract* to *develop* software *products* specifically for reuse.

Note 2: Any *requirement* that calls for the *development* of a software *product* can be met by a *reusable software product* that fulfills the *requirement* and meets the criteria established in the SDP. The *reusable software product* can be used as-is or modified and can be used to satisfy the entire *requirement* or part of the *requirement*.

4.2.5 Assurance of Critical Requirements

1. The *developer* **shall** *identify*, *develop*, and *record* strategies for the following types of critical *requirements*:
   a. *Safety;*
   b. *Security*;
   c. *Privacy protection*;
   d. *Reliability, maintainability, and availability*;
   e. *Dependability*;
   f. Human Systems Integration, including *human factors engineering*; and

g. Mission critical *functional* and *performance requirements* as agreed to by the *acquirer* and *developer* (e.g., *requirements* derived from *Key Performance Parameters (KPPs)*, accuracy *requirements*, and timing *requirements*).

2. The *developer* **shall**:
   a. *identify* those *computer hardware* and *software items* or portions thereof whose failure could lead to violations of the critical *requirements*;
   b. *develop* a strategy, including the development approaches, *tests*, modeling, and analyses, to ensure that the *requirements*, *architecture*, *design*, implementation, and operating procedures for the identified *computer hardware* and *software* minimize or eliminate the potential for such violations;
   c. *record* the strategy in the SDP;
   d. implement the strategy; and
   e. produce evidence, as part of the required computer hardware and software *products*, that the strategy has been successfully carried out.

4.2.6 Computer Hardware Resource Utilization

1. The *developer* **shall** analyze *requirements* and design constraints concerning computer *hardware* resource utilization (such as maximum allowable use of processor capacity, memory capacity, input and output device capacity, auxiliary storage device capacity, and communications and network *bandwidth* capacity).
2. In order to meet the *computer hardware* resource utilization *requirements* and design constraints, the *developer* **shall**:
   a. allocate *requirements* and *design* constraints to *computer hardware* resources,
   b. model the utilization of these resources based on the software *architecture* and *design*,
   c. monitor the utilization of these resources during implementation, integration and *testing*, and *qualification testing*, and
   d. reallocate resources or identify the need for additional resources as necessary.

   Note: All of these activities always include *recording* the information and results even if that is not explicitly stated.
3. The allocated resource utilizations **shall** be managed as *Technical Performance Measures (TPMs)*.

   Note: The *computer hardware* resource utilization examples cited above might not include the complete set of software *TPMs*.

4.2.7 Recording Rationale

1. The *developer* **shall** *record* rationale for key decisions made in specifying, architecting, designing, implementing, *testing*, and deploying the *software*.
2. The rationale **shall** include tradeoffs considered, analysis methods, and criteria used to make the decisions.
3. The rationale **shall** be *recorded* in *documents*, development tools, code comments, or other media that will transition to the *maintenance organization,* whether contractor or *acquirer*.
4. The meaning of "key decisions" and the approach for providing the rationale **shall** be described in the SDP.

4.2.8 Access for Acquirer Review

1. The *developer* **shall** provide the *acquirer* access to all *software team member* facilities, including the *software engineering environment* and *software integration and qualification test environment*, for review of software *products* and activities.
2. The *developer* **shall** provide the *acquirer* electronic access to the draft and final *work products* specified in Section 4 and Section 5 produced by the *developer* and all *software team members* in accordance with the *contractual requirements*.

3. The *developer* **shall** provide the *acquirer* electronic access to the draft and final *work products* together with tools to remotely query, report, and display that data.

Note: These requirements do not negate security policies that apply.

4.2.9 Contractual Requirements for Software

1. The *developer* **shall** plan the approach to be followed for meeting all of the *contractual requirements* regarding software.
2. The *developer* **shall** *record* in the SDP the approach to be followed for meeting all of the *contractual requirements*.

5. Detailed Requirements

The order of the *requirements* in this section is not intended to specify the order in which they must be carried out. Some activities might not be *applicable* to the project or *contracted* effort. Many of the activities can be ongoing at the same time; different software *products* can proceed at different paces; and activities specified in early subsections can depend on input from activities in later subsections. If the *software* is developed in multiple *builds*, some activities might be performed in every *build*, others might be performed only in selected *builds*, and activities and software *products* might not be complete until several or all *builds* are accomplished. Nonmandatory notes throughout Section 5 explain how to interpret each activity on a project involving multiple *builds*. A project involving a single *build* accomplishes all required activities in that *build*.

Note: The wording here and throughout this standard is intended to:

1. emphasize that the development and recording of planning and engineering information is an intrinsic part of the software development process, to be performed regardless of whether a *deliverable product* is required;
2. use the *Data Item Description (DID)* or template as the minimum list of items to be covered in the planning or engineering activity regardless of whether a *CDRL* item delivery is required for the *DID* or template or whether the *DID* or template has been tailored; and
3. permit representations other than traditional *documents* for *recording* the information (e.g., computer-aided engineering (CAE) tools).

5.1 Project Planning and Oversight

This section specifies the developer *requirements* for project planning and oversight.

Note: If a *system* or *software item* is developed in multiple *builds*, planning for each *build* is interpreted to include:

1. overall planning for the *contract*,
2. detailed planning for the current *build*, and
3. planning for future *builds* to a level of detail compatible with the information available.

5.1.1 Software Development Planning

1. The *developer* **shall** *develop* and *record* plans and approaches for conducting the activities required by this standard.
2. The *developer* **shall** *develop* and *record* plans and approaches for conducting the activities required by other software-related *requirements* in the *contract*.
3. The planning for the activities required by this standard **shall** be consistent with *system*-level planning.
4. The planning for the activities required by this standard and by the *contract* **shall** be *documented* in the Software Development Plan (SDP).

   Note: See Section 6.2 for the SDP template identifier.
5. The planning for the activities required by this standard **shall** include all items in the SDP template in Appendix H.1 Software Development Plan Template.
6. The Software Development Plan **shall** be prepared in accordance with the SDP template in Appendix H.1 Software Development Plan Template.
7. The SDP **shall** be an integrated plan covering the *software development* activities for all *software team members* throughout development.
8. The *developer* **shall** *define* and *record* in the SDP the artifacts and other information to be *developed* and *recorded* to satisfy the contents of the software *products* required by this standard.

9. The *developer* **shall** *define* and *record* in the SDP the artifacts and other information to be *developed* and *recorded* to prepare all software-related *deliverable products* required by the *contract*.
10. The *developer* **shall** use the *DID* or template for a *product* as the minimum list of items to be covered in the planning or engineering activity regardless of whether a *CDRL* item delivery is required for the *DID* or template or whether the *DID* or template has been tailored.

5.1.2 Software Integration and Qualification Test Planning

5.1.2.1 Software Integration Planning

This section pertains to unit integration and software-hardware item integration.

1. The *developer* **shall** *develop* and *record* the planned sequence of integration of the:
   a. *software units*,
   b. *software items*, and
   c. *software items* with the *hardware items* on which they execute.
2. The planned integration sequence of *software units*, *software items*, and *hardware items* **shall** be recorded as part of the Software Master Build Plan (SMBP).
3. The software integration planning **shall** include all *applicable* items in Appendix H.3 Software Master Build Plan (SMBP) Template.
   Note: See Section 6.2 for the SMBP template identifier.
4. The *developer* **shall** *record* the integration and test planning for *software units* in the SDFs.

5.1.2.2 Software Item Qualification Test Planning

1. The *developer* **shall** *develop* and *record* plans for conducting software item *qualification testing*.
2. The plans for conducting *software item qualification testing* **shall** be *documented* in the Software Test Plan (STP).
   Note: See Section 6.2 for the STP *DID* identifier.
3. The *software item qualification test* planning **shall** include all *applicable* items in the Software Test Plan (STP) *DID*, as defined in the SDP (see Section 5.1.1).
4. The *software item qualification test* planning **shall** address all *verification method*s, i.e., Inspection (I), Analysis (A), Demonstration (D), and Test (T), necessary to fully verify the software *requirements*, including the software *interface requirements*.
5. The *software item qualification test* planning **shall** address all *verification* levels in the *verification testing* hierarchy (e.g., *build*, *software item*, *subsystem*, *system*) necessary to fully verify the software *requirements*, including software *interface requirements*.
6. The *developer* **shall** plan for *recording* and tracking the cumulative record of the *verification* status, i.e., fully verified, partially verified, not verified, of all software *requirements*, including software *interface requirements*, for:
   a. all *verification testing*, i.e., initial *qualification test* execution, *regression testing*, and retesting,
   b. all *test cases* for all *verification methods*, i.e., Inspection (I), Analysis (A), Demonstration (D), and Test (T); and
   c. all levels in the *verification testing* hierarchy, i.e., *build*, *software item*, *subsystem*, *system*.
7. The *software item qualification test* planning **shall** include criteria for:
   a. *test activity suspension*,
   b. *test activity termination*, and
   c. test activity resumption after suspension and termination (e.g., *test cases*, *test procedures*, and *software* are corrected).

5.1.3 System Qualification Test Planning

1. The *developer* **shall** *participate* in *developing* and *recording* plans for conducting *system qualification testing*.
2. The *system qualification test* planning **shall** address all *verification methods*, i.e., Inspection (I), Analysis (A), Demonstration (D), and Test (T), necessary to fully verify the system *requirements*, including the system interface *requirements*.
3. The *system qualification test* planning **shall** address all *verification* levels in the *verification testing* hierarchy (e.g., *build*, item, *subsystem*, *system*) necessary to fully verify the system *requirements*, including system interface *requirements*.

Note: "*System qualification testing*" in this section is interpreted to mean the *verification* of all levels of *requirements* higher in the *specification tree* than the software *requirements* (e.g., *subsystem*, *system*).

5.1.4 Planning for Software Transition to Operations

1. The *developer* **shall** *develop* and *record* plans for *transitioning software* to operations.
2. The *developer* **shall** specify which *software* is to be fielded, i.e., distributed, to which *user sites*. See Section 5.12.4.
3. The planning for *transition* to operations **shall** include plans for performing:
   a. *software* installation,
   b. *software* and configuration *checkout* at the *user sites*, and
   c. training at the *user sites* specified in the *contract*.
4. The *developer* **shall** plan for *transitions* to operations of *software* deliveries, including *processes* to ensure:
   a. uninterrupted operations through the *transition,* with a planned down time, if any, acceptable to the *acquirer* and *users* for *transition*; and
   b. continuity of operational data through each *transition*.
5. The planning for *transition* to operations **shall** include all *applicable* items in the Software Installation Plan (SIP) *DID*, as defined in the SDP (see Section 5.1.1).
6. The software transition planning and execution **shall** be consistent with the system transition planning and execution.

   Note: See Section 6.2 for the SIP *DID* identifier.

Note 1: If *software* is developed in multiple *builds*, the developer's build planning identifies for each *build* what *software*, if any, is to be fielded, i.e., distributed, to *users* and the extent of fielding (for example, full fielding or fielding to selected evaluators only). Preparing for *software* use for each *build* is interpreted to include those activities necessary to carry out the fielding plans for that *build*.
Note 2: The standard does not cover hardware installation.

5.1.5 Planning for Software Transition to Maintenance

1. The *developer* **shall** *develop* and *record* plans:
   a. identifying the *software development* resources that will be needed by the *maintenance organization* to fulfill the support concept specified in the *contract*, and
   b. describing the approach to be followed for transitioning deliverable items to the *maintenance organization*.
2. The *developer* **shall** plan for:
   a. *software engineering* and *software integration and qualification test environments* at the *maintenance* site, and
   b. *maintaining* the *software engineering* and *software integration and qualification test environments* after development to support *discrepancy* resolution and changes to *software* and operational constants.

3. The planning for *transition* to *maintenance* **shall** include all *applicable* items in the Software Transition Plan (STrP) *DID*, as defined in the SDP (see Section 5.1.1).
   Note: See Section 6.2 for the STrP *DID* identifier.

Note: If *software* is developed in multiple *builds*, the developer's build planning identifies for each *build* what *software*, if any, is to be *transitioned* to the *maintenance organization*. Preparing for *software transition* to *maintenance* for each *build* is interpreted to include those activities necessary to carry out the *transition* plans for that *build*.

5.1.6 Following and Updating Plans

1. The *developer* **shall** conduct the *software development* activities in accordance with the plans in Section 5.1.
2. All *software team members* **shall** conduct the *software development* activities in accordance with the plans in Section 5.1.
3. The *developer* **shall** update the plans in Section 5.1 and any other plans:
   a. whenever changes occur, and
   b. according to the *requirements* in the *contract*.
4. The plans in Section 5.1, including any updates to those plans, **shall** be subject to *approval* according to developer *processes* and, if required in the *contract*, *acquirer approval*.
5. The *developer* **shall** notify the *acquirer* when changes occur to:
   a. plans in Section 5.1, and
   b. the documents and processes referenced in those plans.

5.2 Establishing a Software Development Environment

This section specifies the *requirements* for the *software development* environment. The *software development* environment consists of both the *software engineering environment* and the *software integration and qualification test environment*.

1. The *developer* **shall** *establish* and *maintain* a *software development* environment that provides the resources necessary to perform all activities specified in this standard.
2. In order to ensure that the resources are sufficient to accomplish the software work required by this standard, the *developer* **shall** analyze the adequacy of the planned:
   a. *software engineering environment,* and
   b. *software integration and qualification test environment*.
3. The *developer* **shall** record the results of the adequacy assessments for the *software engineering environment* and *software integration and qualification test environment* in the SDP.

Note: If a *system* or *software item* is developed in multiple *builds*, establishing the *software development* environment in each *build* is interpreted to mean establishing the environment needed to complete that *build.*

5.2.1 Software Engineering Environment

1. The *developer* **shall** *establish*, control, and *maintain* a *software engineering environment* to perform the *software engineering* effort.
2. The developer **shall** keep the tools, including *COTS* and open source tools, in the *software engineering environment* used to produce the *software* current.
3. The *developer* **shall** *demonstrate* that each element of the *software engineering environment* performs its intended functions.
4. The *developer* **shall** *demonstrate* that each element of the *software engineering environment* is ready to perform its intended functions before starting the activity that uses that element.

5.2.2 Software Integration and Qualification Test Environment

1. The *developer* **shall** *establish,* control, and *maintain* a *software integration and qualification test environment* to perform integration and *qualification testing* of *software*.
2. The developer **shall** *demonstrate* that the tools, including *COTS* and open source tools, in the *software integration and qualification test environment* are kept current.
3. The *developer* **shall** *demonstrate* to the *acquirer* that each element of the *software integration and qualification test environment* performs its intended functions.
4. The *developer* **shall** *validate* each element of the *software integration and qualification test environment* that is used in *verification* of *requirements* before the elements are used for that purpose.
5. The *developer* **shall** *demonstrate* that each element of the *software integration and qualification test environment* is ready to perform its intended functions before starting the integration or qualification testing activity that uses that element.

5.2.3 Software Development Library

1. The *developer* **shall** *establish*, control, and *maintain* a *software development library* (*SDL*) to facilitate the orderly development and subsequent *maintenance* of *software*.
   Note: The *SDL may* be an integral part of the *software engineering environment* and *software integration and qualification test environment*.
2. The *developer* **shall** *maintain* the *SDL* throughout the system development lifecycle.

5.2.4 Software Development Files

1. The *developer* **shall** *establish*, control, and *maintain* a *software development file* (*SDF*):
   a. for each *software unit* or logically related group of *software units*,
   b. for each *software item*,
   c. for each *build*,
   d. for logical groups of *software items*, as *applicable*,
   e. for *subsystems*, if *applicable*, and
   f. for the overall *system*.
2. The *developer* **shall** *record* information about the development of the *software* in appropriate *SDFs*.
3. The *developer* **shall** *maintain* the *SDFs* throughout the system development lifecycle.

5.2.5 Nondeliverable Software

1. The *developer* **shall** *demonstrate* that all *nondeliverable* software *products* used perform their intended functions.
2. If any *nondeliverable* software *product* is used in the development of *deliverable* software *products,* then the *developer* **shall** *demonstrate* that:
   a. after delivery to the *acquirer,* the operation and *maintenance* of the *deliverable* software *products* do not depend on the *nondeliverable* software *products*, *or*
   b. the *acquirer* has or can obtain the same *nondeliverable* software *products*.
3. If any *nondeliverable* software *product* is used in the development of *deliverable* software *products,* then the *developer* **shall** *demonstrate* that the nondeliverable *software* has caused no adverse effects to the deliverable *software*
   Note: Examples of these adverse effect include, e.g., corruption of deliverable *software* or data, introduction of viruses, Trojan horses, or other malware.

5.3 System Requirements Analysis

This section specifies the developer *requirements* for *participation* in system requirements analysis.

Note: If a *system* is developed in multiple *builds*, it is possible that its *requirements* are not fully defined until the final *build*. The *developer's* planning identifies the subset of system *requirements* to be defined in each *build* and the subset to be implemented in each *build*. System *requirements* analysis for a given *build* is interpreted to mean defining the system *requirements* so identified for that *build*.

5.3.1 Analysis of User Input[3]

1. The *developer* **shall** *participate* in analyzing user input provided by the *acquirer* to gain an understanding of the *user* needs.

Note 1: This *user* input takes the form of need statements, surveys, *discrepancy and change reports*, feedback on *prototypes*, interviews, or other *user* input or feedback.
Note 2: This *requirement* is intended to ensure that all interested parties maintain ongoing communications regarding *user* needs throughout the development of the *system*. Interested parties include, but are not limited to, the *users*, operators, *acquirer*, *developer*, *maintenance organizations,* and test organizations.

5.3.2 Operational Concept

1. The *developer* **shall** *participate* in *defining* and *recording* the operational concept for the *system*.
2. The results of *defining* and *recording* the operational concept **shall** include all *applicable* items in the Operational Concept Description (OCD) *DID*, as defined in the SDP (see Section 5.1.1).
   Note: See Section 6.2 for the OCD *DID* identifier.

5.3.3 System Requirements Definition

1. Based on the analysis of *user* needs, the operational concepts, and other considerations, the *developer* **shall** *participate* in *defining* and *recording* the *requirements*, including *derived requirements*, to be met by the *system*.
2. The developer **shall** *participate* in *defining* and *recording* the system interface *requirements.*
   Note: An *interface* could be specified in *system* or *subsystem specifications*, as *applicable*, or could be specified in *interface requirements specifications* or interface control *documents* (ICDs).
3. The *developer* **shall** *participate* in *defining* and *recording* the methods to be used for verifying that each system *requirement,* including interface *requirements,* has been met.
4. The results of *defining* and *recording* the *requirements* and *verification methods* **shall** include all *applicable* items in the System/Subsystem Specification (SSS) *DID*, as defined in the SDP (see Section 5.1.1).
   Note: See Section 6.2 for the SSS *DID* identifier.
5. The *developer* **shall** *participate* in the allocation of system *requirements* to hardware, *software*, and manual operations.

Note 1: System *requirements* include both *functional* and *nonfunctional requirements*.
Note 2: If a *system* consists of *subsystems*, the activity in Section 5.3.3 is intended to be performed iteratively with the activities in Section 5.4 (System *Architecture* and *Design*) to define system *requirements*; architect and *design* the *system,* identifying its *subsystems*; allocate the system *requirements* to the identified *subsystems*; *define* the *requirements* for those *subsystems*; architect and *design* the *subsystems, identifying* their *components*; and so on until, in the last iteration, *requirements* are allocated to *hardware items*, *software items*, and manual operations.

5.4 System Architecture and Design

This section specifies the developer *requirements* for participation in system architecture and *design*.

[3]Note 2 is based on information from Section 5.3.1 of (EIA/IEEE J-016).

Note: If a *system* is developed in multiple *builds*, it is possible that its architectural *design* is not fully defined until the final *build*. The *developer's* planning identifies the portion of the system architectural *design* to be defined in each *build*. System architectural *design* for a given *build* is interpreted to mean defining the portion of the *system architecture* and *design* identified for that *build*.

5.4.1 System-wide Architectural Design Decisions

1. The *developer* **shall** *participate* in *defining* and *recording* system-wide architectural *design* decisions, that is, decisions about the *system's behavioral design* and other decisions affecting the selection and *design* of system *components* to meet both *functional* and *nonfunctional requirements*.

   Note: Architectural *design* decisions remain at the discretion of the *developer* unless converted to *requirements*. The *developer* is responsible for fulfilling all *requirements* and demonstrating this fulfillment through *qualification testing* (see Section 5.9 and Section 5.11). Architectural *design* decisions act as developer-internal "*requirements*," to be implemented, imposed on other *software team members*, if *applicable*, and confirmed by unit, unit integration, or software-hardware integration *testing*, but their fulfillment need not be *demonstrated* to the *acquirer*. (See Section 5.7, Section 5.8, and Section 5.10.)
2. The result of *defining* and *recording* system-wide architectural design decisions **shall** include all *applicable* items in the systemwide design decisions section of the System/Subsystem Design Description (SSDD) *DID*, as defined in the SDP (see Section 5.1.1).
   Note: See Section 6.2 for the SSDD *DID* identifier.

5.4.2 System Architectural Design[4]

1. The *developer* **shall** *participate* in *defining* and *recording* the system architectural *design*.
2. The *developer* **shall** *participate* in selecting *software items*, as part of defining the system architectural *design*.
3. The *developer* **shall** *participate* in *defining*:
   a. the architectural approaches that were considered to address the critical and *nonfunctional requirements*, and
   b. the rationale for the selected approach.
4. The *developer* **shall** *participate* in identifying the system architectural design *risks* for the selected architectural *design*.
5. The resulting system *architecture* **shall** include all *applicable* items in the system architectural *design* section of the SSDD *DID*, as defined in the SDP (see Section 5.1.1).

Note 1: For conciseness, this subsection is written in terms of organizing a *system* into *components*. However, this is interpreted to cover organizing a *system* into *subsystems*; organizing a *subsystem* into *hardware items*, *software items*, and manual operations; or other variations as *applicable*.
Note 2: See Section 6.2 for the SSDD *DID* identifier.
Note 3: See Section 4.2.3.1 for the traceability *requirements* between system *requirements and* system architectural *design components*.

5.5 Software Requirements Analysis

This section specifies the developer *requirements* for software *requirements* analysis.

1. Based on the analysis of system *requirements*, the system *architecture* and *design*, the operational concept, and other considerations, the *developer* **shall** *define* and *record* for each *software item*:

[4] This subsection is based on information from Section 5.4.2 of (EIA/IEEE J-016).

a. the software *requirements*, including *functional* and *nonfunctional requirements*, to be met by each *software item*, and
b. the methods and levels for verifying each *requirement.*

Note: See Section 4.2.3.1 for traceability *requirements* for software *requirements*.

2. The *specification* of software *requirements* **shall** include *requirements* derived from trade studies, *architecture*, design decisions, and operational concepts, which might not be directly traceable to higher-level *requirements*.
3. The *specification* of each *derived* software *requirement* **shall** include the traceability and rationale explaining the relationship to the trade studies, system *architecture*, *software architecture*, design decisions, and operational concepts that led to the *derived requirement*.

   Note: See Section 4.2.3.1 for traceability *requirements* for derived *software requirements*.
4. The *developer* **shall** identify the critical software *requirements* for the critical *requirements* categories specified in Section 4.2.5.
5. The software *requirements* analysis result **shall** include all *applicable* items in the Software Requirements Specification (SRS) *DID*, as defined in the SDP (see Section 5.1.1).
6. The software *requirements* analysis result **shall** include all *applicable* items in the Interface Requirements Specification (IRS) *DID*, as defined in the SDP (see Section 5.1.1).

Note 1: If a *software item* is developed in multiple *builds*, its *requirements* might not be fully defined until the final *build*. The *developer's* planning identifies the subset of each *software item's requirements* to be defined in each *build* and the subset to be implemented in each *build*. Software *requirements* analysis for a given *build* is interpreted to mean *defining* the *software item requirements* identified for that *build*.
Note 2: See Section 6.2 for the SRS and IRS *DID* identifiers.
Note 3: If a separate IRS is not used, the software interface *requirements* are specified in SRS Paragraph 3.3 and its subparagraphs.

5.6 Software Architecture and Design

This section specifies the developer *requirements* for software *architecture* and *design*.
Note: If a *software item* is developed in multiple *builds*, its *architecture* and *design* might not be fully *defined* until the final *build*. Software *architecture* and *design* in each *build* is interpreted to mean the *architecture* and *design* necessary to meet the *software item requirements* to be implemented in that *build*.

5.6.1 Overall Software Architecture

1. The *developer* **shall** *define* and *record* the software *architecture* of the complete set of *software* under the *contract*, including all *categories of software*.
2. The resulting overall *software architecture* **shall** include all *applicable* items in Paragraphs 3 through 5 of the Software Architecture Description (SAD) template, as defined in the SDP (see Section 5.1.1).

   Note 1: See Section 4.2.3.2 for traceability *requirements* for the *software architecture*.

   Note 2: See Section 6.2 for the SAD template identifier.
3. The *developer* **shall** update the Software Master Build Plan (SMBP) to reflect the software *architecture* and its impact on integrating the *software items*.

   Note: See Section 6.2 for the SMBP template identifier.

5.6.2 Software Item Architecture

1. The *developer* **shall** *define* and *record* the *software architecture* of each *software item.*
2. The resulting *software architecture* for each *software item* **shall** include all *applicable* items in Paragraphs 3, 4, and 6 of the Software Architecture Description (SAD) template, as defined in the SDP (see Section 5.1.1).

Note 1: See Section 6.2 for the SAD template identifier.

Note 2: See Section 4.2.3.2 for the traceability *requirements* for *software architecture*.

3. The *developer* **shall** update the Software Master Build Plan (SMBP) to reflect the software *architecture* and its impact on integrating the *software units* and *software items*.

   Note: See Section 6.2 for the SMBP template identifier.

5.6.3 Software Item Detailed Design

1. The *developer* **shall** *develop* and *record* the detailed *design* of each *software item*.
2. The detailed *design* of each *software item* **shall** include all *applicable* items in Sections 3 and 4 of the Software Design Description (SDD) *DID* that are not included in the SAD, as defined in the SDP (see Section 5.1.1).
3. The detailed *design* of each *software item* **shall** include all *applicable* items in Section 5 of the Software Design Description (SDD) *DID*, as defined in the SDP (see Section 5.1.1).

   Note 1: See Section 6.2 for the SDD *DID* identifier.

   Note 2: See Section 4.2.3.2 for the traceability *requirements* for each *software unit* covered by the SDD.
4. The detailed *design* of the software item *interfaces* **shall** include all items in the Interface Design Description (IDD) *DID*, as defined in the SDP (see Section 5.1.1).

   Note 1: See Section 6.2 for the IDD *DID* identifier.

   Note 2: If a separate IDD is not used, the software *interface design* are specified in SDD Paragraph 4.3 and its subparagraphs.

   Note 3: See Section 4.2.3.2 for the *traceability requirements* between *interfaces* in the IDD and software item *requirements* that address the *interface*.
5. If the *software item* contains a *user interface*, the detailed *design* of the *software item* **shall** include the *design* of the *user interface* screens and interaction mechanisms, as defined in the SDP (see Section 5.1.1).

   Note: See Section 4.3 of the SDD *DID*.
6. The detailed design of the *software units* that are *databases* or are software units that access or manipulate *databases* **shall** include all items in the Database Design Description (DBDD) *DID*, as defined in the SDP (see Section 5.1.1).

   Note 1: See Section 6.2 for the DBDD *DID* identifier.

   Note 2: See Section 4.2.3.2 for the traceability *requirements* for each *database* or other *software unit* covered by the DBDD.
7. The developer **shall** *record* the software detailed *design* information in the *applicable software development files* (*SDFs*).
8. If changes are needed in *automatically generated code*, the *developer* **shall** modify the *design* in the tool that generated the code, rather than modifying the *automatically generated code*.

   Note: The need for change is identified in a Discrepancy and Change Request (DCR).

5.7 Software Implementation and Unit Testing

This section specifies the developer *requirements* for *software* implementation and *software unit testing*. *Software* implementation activities include such tasks as coding computer instructions, coding data definitions, building *databases*, populating *databases* with data values, creating procedures, populating other data files with values, configuring *COTS* and any other *reusable software*, modifying existing code and data, employing automated code generators, and many other tasks needed to implement the *design*. *Software units* in the *design* do not necessarily have a one-to-one relationship with the code and data entities (e.g., classes, objects, procedures, *databases*, data files) that implement them or with the computer files containing those entities.

Unit *testing* is performed to find any *discrepancies* that escaped peer reviews and to determine whether the *software unit* meets all of its allocated *requirements* and implements its design for both *nominal* and *off-nominal conditions*. Unit *testing* is accomplished for each *software unit* and includes preparing for *testing* the unit, performing the unit *testing* on the *software unit*, analyzing and *recording* the test results, fixing problems, and performing retesting. *Requirements* are also included in this section for *regression testing* the *software unit* if changes (e.g., to the *software* or the *target computer system*) are made after the unit has successfully completed unit *testing* in order to determine whether the changes adversely impact the functioning or performance of the unit. Unit *testing* is an iterative process of initial *testing*, fixing problems in the *software* or test preparation *products* (e.g., test data, *test procedures*), and retesting until the unit *test cases*, including the *nominal* and *off-nominal test cases*, all execute successfully, i.e., with actual results matching *expected results*.

Unit *testing* is usually performed on one *software unit* at a time in isolation. The definition of *software unit* allows for a hierarchy of units, hence some units may need to be tested with other units present.

If a *software item* is developed in multiple *builds*, software implementation and unit *testing* of that *software item* will not be completed until the final *build*. Software implementation and unit *testing* for each *build* is interpreted to include those *software units*, or parts of *software units*, needed to meet the *software item requirements* to be implemented in that *build*.

The terms "unit *test*" and "unit *testing*" refer to the activity of verifying the correctness of the *software unit* implementation. The use of the words "*test*" or "*testing*" in this section is distinct from the *verification method* of Test. The activity of unit *testing* can require the use of all *verification methods*, i.e., Inspection (I), Analysis (A), Demonstration (D), and Test (T).

5.7.1 Implementing Software

1. The *developer* **shall** implement and *record software* corresponding to each *software unit* in the *software item design*.
2. The *developer* **shall** *record* the *software* implementation *products* in the appropriate *software development files* (*SDFs)*.

5.7.2 Preparing for Unit Testing

1. The *developer* **shall** prepare to unit *test* all newly developed *software*.
2. The *developer* **shall** prepare to unit *test* all of the following *reusable software* within the *software unit* for which *source code* or *design* is available:
   a. modified *reusable software*;
   b. *reusable software* where previous *discrepancy and change reports* indicate potential problems, even if the *reusable software* has not been modified;
   c. *reusable software* whose unit *testing* did not satisfy the *requirements* of this section, i.e., Section 5.7.2, of this standard;
   d. *reusable software* partially or fully satisfying a critical requirement (see Section 4.2.5), even if the *reusable software* has not been modified; and
   e. *reusable software* when the adequacy of the unit *testing* is unknown, i.e., whether the *requirements* of this section, i.e., Section 5.7.2, were satisfied is unknown.

   Note: If neither the *source code* nor the *design* is available for *reusable software* in the *software unit*, then unit *testing* with respect to the *design* is not required for that part of the unit.
3. The *developer* **shall** *develop* the following test preparation *products* for *testing* the *software* corresponding to each *software unit*:
   a. instructions for preparing the test environment;
   b. *test cases* for all *verification methods* used for *testing* the *software units*;
   c. *test procedures*;

d. test drivers or test scripts, or both; and
e. test data, including test *databases*.

Note: See Section 4.2.3.3 for traceability *requirements* for *software unit test cases*.

4. For each *software unit* the *developer* **shall** define unit test *equivalence classes* and *representative sets* of *nominal* and *off-nominal conditions,* including, as a minimum, valid and invalid values; values just inside the boundary of acceptable range values, at the boundary, and just outside the boundary; and *extreme values*.
5. The *developer* **shall** base the unit test *equivalence classes* on:
   a. the unit's *source code* for all newly developed *software*, unless the *source code* was automatically generated;
   b. the unit's design for all *automatically generated code* in the unit, whether newly generated or reused;
   c. the unit's code for all *reusable software* where *source code* is available, unless it was automatically generated; and
   d. the unit's design for all *reusable software* where the *source code* is not available.
6. Using these *representative sets* of *nominal* and *off-nominal conditions*, the *developer* **shall** define unit *test cases* that address the unit's *design*, including, as a minimum, correct execution of:
   a. all algorithms;
   b. all *interfaces* internal to the unit, including *interfaces* to *reusable software* within the unit;
   c. all *interfaces* external to the unit;
   d. all statements and branches;
   e. concurrent access of the same data, i.e., reading, adding, updating, and deleting data by multiple *users* or *systems*;
   f. all error and exception handling within the unit;
   g. all fault detection, isolation, recovery (e.g., failover), and data capture and reporting; and
   h. all startup, termination, and restart conditions, when *applicable*.

   Note: To satisfy the above *requirements* for *automatically generated code*, it is strongly recommended that the *developer* make maximum use of the tools provided in the software development environment for analyzing and exercising the *automatically generated code*.
7. Using these *representative sets* of *nominal* and *off-nominal conditions*, the *developer* **shall** define unit *test cases* that address the unit's *requirements*, including, as a minimum, all:
   a. software *requirements,* or the portions thereof, allocated to the unit; and
   b. software *interface requirements,* or the portions thereof, allocated to the unit.
8. The *developer* **shall** define at least one unit *test case* for each unit test *equivalence class* of *nominal* and *off-nominal conditions*.
9. The *developer should* automate the preparation and execution of the unit *test cases*, *test procedures*, test drivers, test scripts, and test data to the extent feasible.
10. The *developer* **shall** record the unit test preparation *products* in the appropriate *SDFs*.

5.7.3 Performing Unit Testing

1. The *developer* **shall** perform unit testing in accordance with the unit test preparation *products* prepared according to the *requirements* in Section 5.7.2 (preparing).
2. The *developer* **shall** repeat the unit testing in accordance with Section 5.7.4 (analyzing and *recording*) and Section 5.7.6 (retesting) until all *test cases* and *test procedures* have been performed successfully, i.e., with actual results matching the *expected results*.

5.7.4 Analyzing and Recording Unit Testing Results

1. For all unit *testing* performed, including initial unit *testing*, *regression testing*, and retesting, the *developer* **shall** perform the following:
   a. analyze the results of unit *testing*, and
   b. identify all *discrepancies* found during unit *testing*.
2. As each unit *test case* and *test procedure* has been performed successfully, i.e., with actual results matching *expected results,* during initial unit *testing*, *regression testing*, and retesting, the *developer* **shall**:
   a. *record* the unit test results in the appropriate *software development files (SDFs)*, and
   b. *record* the unit test analysis results in the appropriate *SDFs*.

5.7.5 Unit Regression Testing

1. For each *software unit*, the unit *regression test suite* **shall** consist of all unit test preparation *products* for that *software unit*, including:
   a. instructions for preparing the test environment;
   b. *test cases* for all *verification methods* used in *regression testing* the *software units*;
   c. *test procedures*;
   d. test drivers or test scripts, or both; and
   e. test data, including test *databases*.
2. The *developer* **shall** update the unit *regression test suite* to reflect new and changed *requirements,* including interface *requirements,* and design.
3. The *developer* **shall** record the unit *regression test suites* in the appropriate *SDFs*.
4. The *developer* **shall** execute the software unit *regression test suite* in accordance with Section 5.7.3 (performing) and Section 5.7.6 (retesting) after any changes, i.e., additions, deletions, or modifications, to:
   a. the previously tested unit,
   b. any *reusable software* included or integrated with the *software unit*,
   c. the *target computer system(s)*, or
   d. the test environment.
5. The *developer should* automate the unit *regression test suite* to the extent feasible.

5.7.6 Revising and Retesting Units

1. Based on the results of unit *testing*, including initial *testing*, *regression testing,* and retesting, the *developer* **shall** make all necessary revisions to the:
   a. *software*;
   b. instructions for preparing the test environment;
   c. *test cases* for all *verification methods* used for retesting the *units*;
   d. test *procedures*;
   e. test drivers or test scripts, or both;
   f. test data, including test *databases*;
   g. *regression test suite; and*
   h. test environment.
2. The *developer* **shall** update the *software development files (SDFs)* as needed to reflect the revisions for *software unit testing*.
3. The *developer* **shall** update other software *products* as needed to reflect the revisions for *software unit testing*.

   Note: Other software *products* include, for example, software *architecture*, *design*, and user manuals.
4. The *developer* **shall** retest the *software unit*:

a. in accordance with Section 5.7.3 (performing) and Section 5.7.4 (analyzing and *recording*), and
b in accordance with the *applicable test cases and test procedures* prepared according to Sections 5.7.2 (preparing), Section 5.7.5 (*regression*), and Section 5.7.6 (retesting).

Note: See Section 5.7.4 for the *requirements* for analyzing and *recording* the unit *testing* activities and results.

5.8 Unit Integration and Testing

This section specifies the developer *requirements* for software unit integration and *testing*. Unit integration and *testing* is performed to integrate the *software* corresponding to two or more *software units*, *testing* the resulting *software* to ensure that it works together as intended, and continuing this process until all *software* in each *software item* is integrated and tested. Unit integration and *testing* is performed in the unit integration sequence specified in the Software Master Build Plan (SMBP) (see Section 5.1.2).

The term "unit integration and *testing*" or "unit I&T" is used throughout this section to refer to the activity of verifying the correct functioning of an integrated collection of units. Unit I&T is an iterative process accomplished for each *software item* and includes preparing for integrating the units, preparing for *testing* the integrated units, integrating the units, *testing* the integrated units, analyzing and *recording* the test results, fixing problems in the *software* or test preparation *products* (e.g., test data, *test procedures*), and retesting until the unit I&T *test cases*, including all *nominal* and *off-nominal test cases*, all execute successfully, i.e., with actual results matching *expected results*. *Requirements* are also included in this section for *regression testing* the integrated units if changes (e.g., to the *software* or the *target computer system(s)*) are made after the integrated units have successfully completed unit integration and *testing* in order to determine whether the changes adversely impact the functioning or performance of the integrated *software units*.

If a *software item* is developed in multiple *builds*, unit I&T of that *software item* will not be completed until the final *build*. Unit I&T for each *build* is interpreted to mean integrating *software* developed in the current *build* with other *software* developed in that and previous *builds*, and *testing* the results. *Software units* from more than one *software item* can be combined in a *build*.

As unit integration and *testing* becomes more complete, the unit integration and test environment evolves to be more and more like the operational environment. The unit integration and test environment is likely to begin on a development computer system, then possibly move to an emulator or a computer system more akin to the *target computer system*, and eventually to the *target computer system(s)*.

The last stage of the unit I&T is called *developer-internal software item integration testing*. If the *software item* is developed in multiple *builds*, then the *developer-internal software item integration testing* occurs on a *build*-by-*build* basis.

Since units can consist of other units, some unit I&T can take place during unit *testing*. The *requirements* in this section are not meant to duplicate those activities.

The use of the words "*test*" or "*testing*" in this section is distinct from the *verification method* of *Test*. The activity of unit integration and testing can require the use of all *verification methods*, i.e., Inspection (I), Analysis (A), Demonstration (D), and Test (T).

5.8.1 Testing on the Target Computer System

The *developer* is strongly encouraged to meet the *requirements* in this section, i.e., Section 5.8.1, as early as possible in unit integration and *testing* (I&T). See the definition of *target computer system* in Section 3.1.

1. Whenever possible, the *developer* **shall** perform unit I&T on the *target computer system(s)* in a configuration as close as possible to the operational configuration.
2. Wherever possible, the *developer* **shall** perform the unit I&T using the actual *interfaces*.
3. If using actual *interfaces* is not possible for unit I&T, then the *developer* **shall** use *high-fidelity simulations* of the *interfaces*.

   Note: See Section 5.2.2 for *validation requirements* for simulations, simulators, and other software used for *verification* of *requirements*.
4. The *developer* **shall** conduct all *developer-internal software item integration testing* under conditions as close as possible to those that the *software* will encounter in the operational environment, i.e., *target computer system(s)*, operational data constants, operational input and output data rates, operational scenarios.

5.8.2 Preparing for Unit Integration and Testing

1. The *developer* **shall** prepare to perform unit I&T on:
   a. all newly developed *software*, and
   b. all modified and unmodified *reusable software*, including *COTS software*.
2. The *developer* **shall** prepare for integrating the *software units* in accordance with the integration sequence recorded in the Software Master Build Plan (SMBP) (see Section 5.1.2).
3. The *developer* **shall** *develop* the following test preparation *products* for conducting unit I&T:
   a. instructions for preparing the test environment;
   b. *test cases* for all *verification methods* used for unit I&T;
   c. *test procedures*;
   d. test drivers or test scripts, or both; and
   e. test data, including test *databases*.

   Note: See Section 4.2.3.3 for traceability *requirements* for software unit I&T.
4. The *developer* **shall** *define* and *record* unit I&T *equivalence classes* and *representative sets* of *nominal* and *off-nominal conditions*, including valid and invalid values; values just inside the boundary of acceptable range values, at the boundary, and just outside the boundary; and *extreme values*.
5. Using these *representative sets* of *nominal* and *off-nominal conditions*, the *developer* **shall** *define* and *record* unit I&T *cases* that address the software *design*, including, as a minimum, correct execution of:
   a. all algorithms;
   b. all *end-to-end functional capabilities* through the *software units* under *test*;
   c. all software *interfaces* among the *software units* under *test*;
   d. all software *interfaces* external to the *software units* under *test*;
      Note: *Testing* the external *interfaces* early in the integration sequence is encouraged.
   e. scenarios containing multiple *users* or functions that must execute concurrently, using normal and heavy operational workloads;
   f. concurrent access of the same data, i.e., reading, adding, updating, and deleting data by multiple *users* or functions in the *software units* under *test*, using normal and heavy operational workloads;
   g. all integrated error and exception handling across the *software units* under *test*;
   h. all fault detection, isolation, recovery (e.g., failover), and data capture and reporting;
   i. all startup, termination, and restart conditions, when *applicable*;
   j. all relevant stress conditions, including worst-case scenarios (e.g., extreme workloads, high frequency of inputs and events, large number of *users*, simulated failed hardware, missing or malfunctioning *interfaces,* tight timelines); and
   k. *endurance testing* using normal and heavy operational workloads.

6. Using these *representative sets* of *nominal* and *off-nominal conditions*, the *developer* **shall** define unit I&T *cases* that address the *software requirements,* or portions thereof, allocated to the *software units* under *test*, including, as a minimum, all:
   a. software *requirements;*
   b. software interface *requirements*;
   c. *performance requirements*, including timing and accuracy *requirements*;
   d. *computer hardware* resource utilization measurement *requirements* (e.g., CPU, memory, storage, *bandwidth*); and
   e. software specialty engineering *requirements* (e.g., *supportability, testability, dependability, reliability, maintainability, availability, safety, security,* and human system integration, including *human factors engineering*, as *applicable*).
7. The unit I&T *cases* to be executed **shall** include at least one *test case* for each unit I&T *equivalence class* of *nominal* and *off-nominal conditions.*
8. The *developer* **shall** define unit I&T *cases* to determine whether the *software* under *test* is impacted by unrequired functionality in *COTS software* or any other *reusable software*.
9. The *developer* **shall** generate and prepare the *software* from the controlled configuration management system for the unit I&T environment, including:
   a. executable *software*;
   b. procedures, if any;
   c. data files, including *databases*; and
   d. other *software* files needed to install, operate, and *test* the *software* on its *target computer system(s)*.
10. The *developer* **shall** automate the *test cases*, *test procedures*, test drivers, test scripts, and test data to the extent feasible.
11. The *developer* **shall** *record* the software unit I&T preparation results in the appropriate *software development files* (*SDFs)*.

5.8.3 Performing Unit Integration and Testing

1. The *developer* **shall** integrate the units in accordance with the unit integration sequence in the Software Master Build Plan (SMBP). See Section 5.1.2.
2. The *developer* **shall** perform testing of the integrated units in accordance with the *test cases* and *test procedures* prepared according to the *requirements* in Section 5.8.2.
3. For all unit integration and testing performed, including initial *testing*, *regression testing*, and retesting, the *developer* **shall** *record*:
   a. a complete unit I&T test log as the unit integration and *testing* proceeds;
   b. in this test log, as a minimum, the test log information specified in Appendix F, Section F.2 for unit I&T;
   c. in this test log all *test incidents* found during unit I&T, whether or not they are resolved during this activity;
   d. in this test log all instances, if any, of *test incidents* with the same symptoms, whether or not they are resolved during this activity; and
   e. in this test log references to all *discrepancy and change reports*, whether or not they are resolved during this activity.
4. The *developer* **shall** repeat the unit I&T testing in accordance with Section 5.8.4 (analyzing and *recording*) and Section 5.8.6 (retesting) until all *test cases* and *test procedures* have been performed successfully, i.e., with actual results matching the *expected results*.

5.8.4 Analyzing and Recording Unit Integration and Test Results

1. For all unit integration and *testing* performed, including initial *testing*, *regression testing*, and

retesting, the *developer* **shall**:

a. analyze the results of unit I&T;
b. *record* in *discrepancy and change reports* all *discrepancies* found during unit I&T, whether or not they are resolved during this activity;
c. *record* in each *discrepancy and change report*, as a minimum, the *discrepancy and change report* information specified in Appendix C, Section C.2 for unit I&T;
d. *record* the unit I&T results in the appropriate *SDFs*; and
e. *record* the unit I&T analysis results in the appropriate *SDFs*.

5.8.5 Unit Integration Regression Testing

1. The *developer* **shall** define a unit I&T *regression test suite*, including:
   a. instructions for preparing the test environment;
   b. *test cases* for all *verification methods* used for unit I&T *regression testing*;
   c. *test procedures*;
   d. test drivers or test scripts, or both; and
   e. test data, including test *databases*.
2. The *developer* **shall** update the unit I&T *regression test suite* to reflect new and changed *requirements*, including interface *requirements*, and *design*.
3. The *developer* **shall** *record* the unit I&T *regression test suite* in the appropriate *SDFs*.
4. The *developer* **shall** execute the unit I&T *regression test suite* in accordance with Section 5.8.3 (performing) and Section 5.8.6 (retesting) after any changes, i.e., additions, deletions, or modifications, to:
   a. any units that previously underwent unit I&T;
   b. any *reusable software* included or integrated with the *software units*;
   c. the *target computer system(s)*; or
   d. the *software integration and qualification test environment*.
5. The *developer* **shall** execute the unit I&T *regression test suite* after other *software units* have been added to the previously integrated and tested *software units*.
6. The *developer* **shall** execute the unit I&T *regression test suite* for *developer-internal software integration testing*.

   Note: For *software* developed in *builds*, this *requirement* will be performed on a *build*-by-*build* basis.
7. The *developer* **shall** automate the unit I&T *regression test suite* to the extent feasible.

Note: See Section 5.8.4 for the *requirements* for analyzing and recording the unit I&T activities and results.

5.8.6 Revising and Retesting Unit Integration

1. Based on the results of unit I&T, including *regression testing* and retesting, the *developer* **shall** make all necessary revisions to the:
   a. *software*;
   b. instructions for preparing the test environment;
   c. *test cases* for all *verification methods* used for unit I&T retesting;
   d. test *procedures*;
   e. test drivers or test scripts, or both;
   f. test data, including test *databases*;
   g. *regression test suite*; and
   h. test environment.
2. The *developer* **shall** update the *SDFs* as needed to reflect the revisions for unit I&T.

3. The *developer* **shall** update other software *products* as needed to reflect the revisions for unit I&T.
4. The *developer* **shall** retest the integrated *software units*:
   a. in accordance with Section 5.8.3 (performing) and Section 5.8.4 (analyzing and *recording*), and
   b. in accordance with the *applicable test cases and test procedures* prepared according to Section 5.8.2 (preparing), Section 5.8.5 (*regression*), and Section 5.8.6 (retesting).

Note: See Section 5.8.4 for the *requirements* for analyzing and recording the unit I&T activities and results.

5.9 Software Item Qualification Testing

This section specifies the developer *requirements* for *software item qualification testing* (*SIQT*). *Software item qualification testing* is performed to verify that the *software item requirements* have been met. *Software item qualification testing* can also be performed to *demonstrate* to the *acquirer* or other stakeholders that *software item requirements* have been met. The stakeholders required to witness *SIQT* depend upon *contract* provisions. *SIQT* addresses the *verification* of *software item requirements* in Software Requirements Specifications (SRSs) and the software-related *interface requirements* in Interface Requirements Specifications (IRSs). This *software item qualification testing* contrasts with *developer-internal software item integration testing*, performed as the final stage of unit integration and *testing* (I&T).

SIQT is usually performed on a *software item* before delivering it to the *acquirer* or for integration with interfacing *software items* or integration at a higher level of integration and *testing*, e.g., software-hardware item I&T. The *developer* can also perform *SIQT* when *software items* are not being delivered to the *acquirer* or for integration outside the *software item*.

The term "*software item qualification testing*" refers to the activity of verifying that the *software item requirements*, including the software *interface requirements* have been met. *Software item qualification testing* is an iterative process accomplished for each *software item* and includes preparing for *testing* the *software item*, dry running the *software item test cases*, *testing* the *software item*, analyzing and *recording* the test results, fixing problems in the *software* or test preparation *products* (e.g., test data, *test procedures*), and retesting until the *software item qualification test cases*, including all *nominal* and *off-nominal test cases*, all execute successfully, i.e., with actual results matching *expected results*. *Requirements* are also included in this section for *regression testing* the *software item* if changes (e.g., to the *software* or the *target computer system(s)*) are made after the *software item* has successfully completed *software item qualification testing* in order to determine whether the changes adversely impact the previously verified *software requirements* or *software interface requirements*.

The activities in Section 5.9.5, Performing Software Item Qualification Testing, are sometimes called "formal execution" or "run for record."

If a *software item* is developed in multiple *builds*, its *software item qualification testing* will not be completed until the final *build* for that *software item* or possibly until later *builds* involving items with which the *software item* is required to *interface*. *Software item qualification testing* for each *build* is interpreted to mean planning and performing tests of the current *build* of each *software item* to ensure that the *software item requirements* to be implemented in that *build* have been met.

The use of the words "*test*" or "*testing*" in this section is distinct from the *verification method* of Test. The activity of *software item qualification testing* can require the use of all *verification methods,* i.e., Inspection (I), Analysis (A), Demonstration (D), and Test (T).

See Appendix E, Section E.3.4 for the Software Build Test Readiness Review (SBTRR) *requirements*.

5.9.1 Independence in Software Item Qualification Testing

1. The individual(s) responsible for *qualification testing* of a given *software item* **shall** be different individual(s) than those who performed detailed *design*, implementation, unit *testing*, or unit integration and *testing* of that *software item*.

   Note: This *requirement* does not preclude the individuals who developed one *software item* from assisting the qualification testers in *qualification testing* the *software item*.

5.9.2 Testing on the Target Computer System

See the definition of *target computer system* in Section 3.1.

1. The *developer* **shall** perform *SIQT* using the *target computer system(s)* in the operational configuration.
2. The *developer* **shall** conduct all *SIQT* under conditions representative of those that the *software* will encounter in the operational environment (e.g., operational data constants, operational input and output data rates, operational scenarios).
3. The *developer* **shall** perform *SIQT* using actual *interfaces* whenever possible.
4. If using actual *interfaces* is not possible for *SIQT*, then the *developer* **shall** use validated *high-fidelity simulations* of the *interfaces*.

   Note: See Section 5.2.2 for *validation requirements* for simulations, simulators, and other *software* used for *verification* of *requirements*.
5. *SIQT* **shall** be performed with the entire *software item* under test installed in the *target computer system(s)*.

   Note: For *software* developed in multiple *builds*, this *requirement* might not be met until the final *build*.
6. The *target computer system(s)* used for *SIQT* **shall** be in the operational software configuration, including all other *software* executing on the *target computer system(s)* (e.g., operating system, *COTS software* and any other *reusable software*, and other *software items*) in addition to the entire *software item* under *test*.
7. The following **shall** be documented in the Software Test Plan (STP) for *SIQT*:
   a. the configuration of all *software,* the *software item* under *test* and all the other *software* included on the *target computer system(s)*;
   b. the *target computer system(s)* and their configurations;
   c. the hardware in the *software item qualification test environment* and its configuration, including calibration dates, as *applicable*;
   d. the *software item qualification test environment software* and its configuration; and
   e. the conditions representing the operational environment (e.g., operational data constants, operational input and output data rates, operational scenarios).

   Note: See Section 6.2 for the STP *DID* identifier.

5.9.3 Preparing for Software Item Qualification Testing

1. The *developer* **shall** prepare *SIQT test cases* to verify all *software requirements* (e.g., in SRSs), and software-related interface *requirements* (e.g., in IRSs and Interface Control Documents), whether they are implemented by *reusable software* or newly developed *software*.
2. The *developer* **shall** prepare to perform *SIQT* on:
   a. all newly developed *software*, and
   b. all modified and unmodified *reusable software*, including *COTS software*.
3. The *developer* **shall** *develop* the following test preparation *products* for conducting *SIQT*:
   a. instructions for preparing the test environment;
   b. *test cases* for all *verification methods* used for *SIQT*;

c. *test procedures*;
d. test drivers or test scripts, or both; and
e. test data, including test *databases*.

Note: See Section 4.2.3.3 for traceability *requirements for SIQT*.

4. The *SIQT* preparation *products* **shall** be in accordance with the Software Test Plan (STP) (see Section 5.1.2).
5. The *developer* **shall** *define SIQT equivalence classes* and *representative sets* of *nominal* and *off-nominal conditions*, including valid and invalid values; values just inside the boundary of acceptable range values, at the boundary, and just outside the boundary; and *extreme values*.
6. Using these *representative sets* of *nominal* and *off-nominal conditions*, the *developer* **shall** *define SIQT test cases* that address, as a minimum, correct execution of:
   a. all *end-to-end functional capabilities* through the *software item* under *test*;
   b. scenarios containing multiple *users* or functions that must execute concurrently, using normal and heavy operational workloads;
   c. concurrent access of the same data, i.e., reading, adding, updating, and deleting data by multiple *users* or functions in the *software item* under *test*;
   d. all integrated error and exception handling across the *software item* under *test*;
   e. all fault detection, isolation, recovery (e.g., failover), and data capture and reporting;
   f. all startup, termination, and restart conditions, when *applicable*;
   g. all *stress testing*, including worst-case scenarios (e.g., extreme workloads, high frequency of inputs and events, large number of *users*, simulated failed hardware, missing or malfunctioning *interfaces*, tight timelines); and
   h. all *endurance testing* using normal and heavy operational workloads.
7. Using these *representative sets* of *nominal* and *off-nominal conditions*, the *developer* **shall** *define SIQT test cases* that address the software *requirements,* or portions thereof, allocated to the *software item* under *test*, including, as a minimum, all:
   a. software *requirements*;
   b. software interface *requirements* internal to the *software item*;
   c. software interface *requirements* external to the *software item*;
   d. performance *requirements*, including timing and accuracy *requirements*;
   e. *computer hardware* resource utilization measurement *requirements* (e.g., CPU, memory, storage, *bandwidth*); and
   f. software specialty engineering *requirements* (e.g., *supportability, testability, dependability, reliability, maintainability, availability, safety, security,* and human system integration, including *human factors engineering*, as *applicable*).
8. The *SIQT* cases to be executed **shall** include at least one *test case* for each *SIQT equivalence class* of *nominal* and *off-nominal conditions.*
9. The *developer* **shall** *define SIQT cases* to determine whether the *software item* under *test* is impacted by unrequired functionality in *COTS software* or any other *reusable software*.
10. The *developer* **shall** generate and prepare the *software* from the controlled configuration management system for the *software item qualification test environment*, including:
    a. executable *software*;
    b. procedures, if any;
    c. data files, including *databases*; and
    d. other *software* files needed to install, operate, and test the *software* on its *target computer system(s)*.
11. The *developer*'s software quality assurance (SQA) personnel **shall** verify the configurations of the hardware, *software*, and *software item qualification test environment*, including:

a. verifying that the *software* was generated following the configuration management procedures,
b. verifying that the *software* checksums match the configuration management checksums,
c. verifying that the *build* identifier of the *software* under *test* is the same as the *build* identifier for the *software* generated from the controlled configuration management system, if a *software* checksum is not available, and
d. verifying that the *software item qualification test environment* configuration matches that specified in the *test procedures documented* in the STD *DID*.

12. The *developer* **shall** provide the *acquirer* a minimum of two weeks of advance notice of the exact time and location of:
    a. formal *SIQT* dry runs;
    b. the Software Build Test Readiness Review (SBTRR) for *SIQT;* (See Appendix E.3.4.)
    c. initial *SIQT* execution; and
    d. resumption of any *SIQT (formal dry runs, initial, regression, or* retesting) after a break of more than two weeks.

    Note 1: The *developer* provided the planned review and testing schedule earlier.
    Note 2: The *developer* and *acquirer* can mutually agree upon a different advance notification length of time for the SBTRR and *SIQT*.
13. The *developer* **shall** automate the *SIQT test cases*, *test procedures*, test drivers, test scripts, and test data to the extent feasible.
14. The *developer* **shall** record the results of preparing for *SIQT* in the Software Test Description (STD), including all *applicable* items in the STD *DID*, as defined in the SDP (see Section 5.1.1).
    Note: See Section 6.2 for the STD *DID* identifier.

5.9.4 Dry Run of Software Item Qualification Testing

1. The *developer* **shall** dry run the *SIQT* of each *software item* in accordance with the *SIQT test cases* and *test procedures* prepared according to Section 5.9.3 to *demonstrate* that:
    a. the *test cases and test procedures* are complete and accurate, and
    b. the *software* is ready for witnessed *testing*.
2. The *developer* **shall** dry run all of the *SIQT test cases* successfully, i.e., with actual results matching *expected results,* using the version of the *software item* undergoing *SIQT* before performing:
    a. *SIQT* execution, according to Section 5.9.5;
    b. *regression testing,* according to Section 5.9.7; and
    c. any retesting, according to Section 5.9.8.

5.9.5 Performing Software Item Qualification Testing

Note: The activities in this subsection are sometimes called “formal execution” or “run for record.”

1. A Software Build Test Readiness Review (SBTRR) **shall** be held before performing the *SIQT*.
    Note: See Appendix E, Section E.3.4 for the SBTRR *requirements*.
2. The *developer* **shall** perform *SIQT* of each *software item* in accordance with:
    a. the *SIQT* plan prepared according to Section 5.1.2, and
    b. the *test cases* and *test procedures* prepared according to Section 5.9.3.
3. The *developer*’s software quality assurance (SQA) personnel **shall** verify that all prerequisite conditions are met for each test case.
4. The *developer*’s SQA personnel **shall** witness the *SIQT*.
5. The *developer* **shall** suspend the *SIQT* if a situation occurs during *SIQT* that causes any of the suspension criteria defined during the software test planning (see Section 5.1.2) to be triggered.

6. The *developer* **shall** terminate the *SIQT* if a situation occurs during *SIQT* that causes any of the termination criteria defined during the software test planning (see Section 5.1.2) to be triggered.
7. The *developer* **shall** terminate the *SIQT* execution if any *test incident* or *test interruption* occurs that requires any change of *software*, hardware, test environment, or configuration.
8. The *developer* **shall** resume *SIQT* after a suspension or termination only after:
   a. SQA personnel have verified the configurations of the *software*, hardware, and *software item qualification test environment*, and
   b. the resumption criteria defined during the software test planning are met (see Section 5.1.2).
9. The *developer* **shall** record corrections to *test procedure* steps as *redlines* in the *test procedure*.
10. As qualification *testing* proceeds, the *developer* **shall** *record* the *SIQT* results as annotations to the *test procedures*, including:
    a. the results of each *test procedure* step,
    b. all differences found between *documented test procedure* steps and actual *test procedure* steps as executed, and
    c. all differences found between the *expected results documented* in the *test procedure* and the actual results as executed.
11. For all *SIQT* performed, including dry runs, initial *SIQT* execution, *regression testing*, and retesting, the *developer* **shall** *record*:
    a. a complete *SIQT test* log of *SIQT* as it proceeds;
    b. in the *SIQT test* log, as a minimum, the test log information specified in Appendix F, Section F.2 for *SIQT*;
    c. in the *SIQT test* log all *test interruptions* during *SIQT*;
    d. in the *SIQT test* log all *test incidents* found during *SIQT*, whether or not they are resolved during this activity;
    e. in the *SIQT test* log all instances, if any, of *test incidents* with the same symptoms, whether or not they are resolved during this activity; and
    f. in the *SIQT test* log references to all *discrepancy and change reports*, whether or not they are resolved during this activity.
12. The *developer* **shall** repeat the *SIQT* in accordance with Section 5.9.6 (analyzing) and Section 5.9.8 (retesting) until all *test cases* and *test procedures* have been performed successfully, i.e., with actual results matching *expected results*.

5.9.6 Analyzing and Recording Software Item Qualification Test Results

1. For all *SIQT* performed, including dry runs, initial *SIQT* execution, *regression testing*, and retesting, the *developer* **shall**:
   a. analyze the *SIQT* results;
   b. *record* for each *requirement* identifier whether it passed or failed;
   c. *record* in *discrepancy and change reports* all *discrepancies* found during *SIQT* execution or analysis, whether or not they are resolved during this activity;
   d. *record* in each *discrepancy and change report*, as a minimum, the information specified in Appendix C, Section C.2 for *SIQT*;
   e. *record* and maintain a cumulative record of the *verification* status, i.e., fully verified, partially verified, not verified, of each software *requirement*, including software interface *requirements*, for:

(1) all *SIQT*, including initial test execution, *regression testing*, and retesting;
(2) all *test cases* for all *verification methods* used for *SIQT*, i.e., Inspection (I), Analysis (A), Demonstration (D), and Test (T); and
(3) all levels in the *verification testing* hierarchy (e.g., *build*, *software item*, *subsystem*, and *system*) (see Section 5.1.2);

f. *record* the *SIQT* results in the Software Test Report (STR), including all *applicable* items in the STR *DID*, as defined in the SDP (see Section 5.1.1);

Note: See Section 6.2 for the STR *DID* identifier;

g. *record* the *SIQT* analysis results in the Software Test Report (STR), including all *applicable* items in the STR *DID*, as defined in the SDP (see Section 5.1.1); and
h. *record* all additional *SIQT* analysis results (e.g., from dry runs and *regression tests*) in the appropriate *SDFs*.

5.9.7 Software Item Qualification Regression Testing

1. The *developer* **shall** define a *SIQT regression test suite*, including:
   a. instructions for preparing the *software item qualification test environment*;
   b. *test cases* for all *verification methods* used for *regression testing* the *software item*;
   c. *test procedures*;
   d. test drivers or test scripts, or both; and
   e. test data, including test *databases*.
2. The *developer* **shall** update the *SIQT regression test suite* to include new and changed *requirements,* including software interface *requirements*, *architecture*, and *design*.
3. The *developer* **shall** automate the *SIQT regression test suite* to the extent feasible.
4. The *developer* **shall** *record* the *SIQT regression test suite* in the appropriate *SDFs*.
5. The *developer* **shall** execute the *SIQT regression test suite* in accordance with Section 5.9.5 (performing) and Section 5.9.8 (retesting) after any changes, i.e., additions, deletions, or modifications, to:
   a. any *software* in the *software item* that has been previously *qualification tested*,
   b. any *reusable software* included or integrated with the *software item*,
   c. any other *software*, including test *software* and other *software items* executing on the *target computer system(s)* in addition to the *software item* under *test,*
   d. the *target computer system(s)* or their configuration(s), or
   e. the *SIQT environment*.
6. All of the *SIQT test cases* **shall** be dry run successfully, i.e., with actual results matching *expected results,* on the latest version of the *software item* undergoing *test* before performing:
   a. *SIQT* execution, according to Section 5.9.5;
   b. *SIQT regression testing*, according to Section 5.9.7; and
   c. any *SIQT* retesting, according to Section 5.9.8.
7. At the culmination of any *build* that is to be delivered for integration with interfacing *software items* or integration at a higher level of integration and *testing*, e.g., software-hardware item integration and testing, delivered to operations, or formally delivered to the *acquirer*, the *developer* **shall** execute the *SIQT regression test suite* to *demonstrate* that any changes, i.e., additions, deletions, or modifications, to the *software* in that *build* have not affected any *requirements* verified in previous *builds*.

Note: See Section 5.9.6 for the *requirements* for analyzing and *recording* the *SIQT* activities and results.

5.9.8 Revising and Retesting Software Items

1. Based on the results of *SIQT*, including dry runs, initial software *qualification test* execution, *regression testing*, and retesting, the *developer* **shall** make necessary revisions to the:
   a. *software*;
   b. instructions for preparing the test environment;
   c. *test cases* for all *verification methods* used for retesting the *software item*,
   d. test *procedures*;
   e. test drivers or test scripts, or both;
   f. test data, including test *databases*;
   g. *regression test suite*; and
   h. *software item qualification test environment*.
2. The *developer* **shall** update the *test documentation* as needed to reflect the revisions for *SIQT*, including:
   a. *SDFs*,
   b. STDs, and
   c. STRs,
3. The *developer* **shall** update other software *products* as needed to reflect the revisions for *SIQT*.
4. The *developer* **shall** retest the *software item*:
   a. in accordance with Section 5.9.5 (performing) and Section 5.9.6 (analyzing and *recording*), and
   b. in accordance with the *applicable SIQT test cases* and *test procedures* prepared according to Sections 5.9.3 (preparing), Section 5.9.7 (*regression*), and Section 5.9.8 (retesting).

Note: See Section 5.9.6 for the *requirements* for analyzing and *recording* the *SIQT* activities and results.

5.10 Software-Hardware Item Integration and Testing

This section specifies the developer *requirements* for software-hardware item integration and *testing*. Software-hardware item integration and *testing* is performed to integrate two or more *software items* and *hardware items* and to *test* the resulting integrated *software* and *hardware items* to ensure that they work together as intended. This process continues until all *software items* and *hardware items* in the *system* are integrated and *tested*.

The term "software-hardware item integration and *testing*" or "software-hardware item I&T" refers to the activity of verifying the correct functioning of an integrated collection of *software items* and *hardware items* or portions thereof.

Software-hardware item I&T is an iterative process accomplished for combinations of *software items* and *hardware items*, and includes preparing for integrating the *software* and *hardware items,* preparing for *testing* the integrated *software* and *hardware items*, integrating the items, *testing* the integrated items, analyzing and recording the test results, fixing problems in the *software, hardware,* or test preparation *products* (e.g., test data, *test procedures*), and retesting until the software-hardware item I&T *test cases*, including all *nominal* and *off-nominal test cases*, all execute successfully, i.e., with actual results matching *expected results*. *Requirements* are also included in this section for *regression testing* the integrated items if changes (e.g., to the *software, target computer system(s)*, or other hardware) are made after the integrated items have successfully completed software-hardware item integration and *testing* in order to determine whether the changes adversely impact the functioning or performance of the integrated items.

As software-hardware item integration and *testing* becomes more complete, the software-hardware integration and test environment evolves to be more and more like the operational environment.

The use of the words "*test*" or "*testing*" in this section is distinct from the *verification method* of Test. The activity of software-hardware item integration and *testing* can require the use of all *verification methods*, i.e., Inspection (I), Analysis (A), Demonstration (D), and Test (T).

If a *system* or *software item* is developed in multiple *builds*, software-hardware item I&T will not be complete until the final *build*. Software-hardware item I&T in each *build* is interpreted to mean integrating the current *build* of each *software item* with the current *build* of other *software items* and *hardware items* and *testing* the results. See Section 5.1.2 for the software-hardware integration sequence.

The last stage of this software-hardware item I&T is *developer-internal system integration testing*. If the *system* is developed in multiple *builds*, then the *developer-internal system integration testing* will occur on a *build*-by-*build* basis.

This software-hardware item I&T activity addresses *software item*-to-*software item*, and *software item*-to-*hardware item* I&T. It does not address *hardware item*-to-*hardware item* I&T.

See Section 1.2.5.2 for interpretation of "*participate.*"

5.10.1 Testing on the Target Computer System

Note: The *developer* is strongly encouraged to meet the *requirements* in Section 5.10.1 as early as possible in software-hardware item integration and *testing*.

See the definition of *target computer system* in Section 3.1.

1. Software-hardware item I&T **shall** be performed on the *target computer system(s)* in the operational configuration(s).
2. Software-hardware item I&T **shall** be performed using the *operational hardware* with which the *software* must interface.
3. The software-hardware item I&T **shall** use actual *interfaces* whenever possible.
4. If using actual hardware *interfaces* is not possible for software-hardware item I&T, then *high-fidelity simulations* of the *interfaces* **shall** be used.
   Note: See Section 5.2.2 for *validation requirements* for simulations, simulators, and other *software* used for *verification* of *requirements*.
5. All software-hardware item I&T **shall** be conducted under conditions representative of those that the *software* will encounter in the operational environment (e.g., operational data constants, operational input and output data rates, operational scenarios).

5.10.2 Preparing for Software-Hardware Item Integration and Testing

1. The *developer* **shall** prepare to perform software-hardware item I&T on:
   a. all newly developed *software*; and
   b. all modified and unmodified *reusable software*, including *COTS software*.
2. The *developer* **shall** prepare for integrating the *software items* and *hardware items* in accordance with the integration sequence recorded in the Software Master Build Plan (SMBP) (see Section 5.1.2).
3. The *developer* **shall** *participate* in developing the following test preparation *products* for conducting software-hardware item integration and *testing*:
   a. instructions for preparing the test environment;
   b. *test cases* for all *verification methods* used for software-hardware item I&T;
   c. *test procedures*;
   d. test drivers or test scripts, or both; and
   e. test data, including test *databases*.
   Note: See Section 4.2.3.3 for traceability *requirements for* software-hardware item I&T.

4. The *developer* **shall** *define* and *record* software-hardware item integration and *testing equivalence classes* and *representative sets* of *nominal* and *off-nominal conditions,* including valid and invalid values; values just inside the boundary of acceptable range values, at the boundary, and just outside the boundary; and *extreme values*.
5. Using these *representative sets* of *nominal* and *off-nominal conditions*, the *developer* **shall** *define* and *record* software-hardware item integration *test cases* that address the software-hardware item *design*, including, as a minimum, correct execution of:
    a. all algorithms;
    b. all *end-to-end functional capabilities* through the *software* and *hardware items* under *test*;
    c. all *interfaces* among the *software* and *hardware items* under *test*;
    d. all software *interfaces* external to the *software* and *hardware items* under *test*;
    e. scenarios containing multiple *users* or functions that must execute concurrently using normal and heavy operational workloads;
    f. concurrent access of the same data, i.e., reading, adding, updating, and deleting data by multiple *users* or functions in the *software* and *hardware items* under *test,* using normal and heavy operational workloads;
    g. all integrated error and exception handling across the *software* and *hardware items* under *test*;
    h. all fault detection, isolation, recovery (e.g., failover), and data capture and reporting;
    i. all startup, termination, and restart conditions, when *applicable*;
    j. all relevant stress conditions, including worst-case scenarios (e.g., extreme workloads, high frequency of inputs and events, large number of *users*, simulated failed hardware, missing or malfunctioning *interfaces*, tight timelines); and
    k. *endurance testing* using normal and heavy operational workloads.
6. Using these *representative sets* of *nominal* and *off-nominal conditions*, the *developer* **shall** define software-hardware item integration *test cases* that address the *requirements*, or portions thereof, allocated to the *software* and *hardware items* under *test*, including, as a minimum, all:
    a. software *requirements*;
    b. interface *requirements* among the *software* and *hardware items* under *test*;
    c. software interface *requirements* external to the *software* and *hardware items* under *test*;
    d. *performance requirements*, including timing and accuracy *requirements*;
    e. *computer hardware* resource utilization measurement *requirements* (e.g., CPU, memory, storage, *bandwidth*); and
    f. software specialty engineering *requirements* (e.g., *supportability, testability, dependability, reliability, maintainability, availability, safety, security,* and human system integration, including *human factors engineering*, as *applicable*).

    Note: Testing external interfaces early in the integration sequence is encouraged.
7. The software-hardware I&T *cases* **shall** include at least one software-hardware item I&T *case* for each software-hardware item I&T *equivalence class* of *nominal* and *off-nominal conditions.*
8. The *developer* **shall** define software-hardware I&T *cases* to determine whether the *software items* and *hardware items* under *test* are impacted by unrequired functionality in *COTS software* or any other *reusable software*.
9. The *developer* **shall** generate and prepare the *software* from the controlled configuration management system for the software-hardware I&T environment, including:
    a. executable *software*;
    b. procedures, if any;
    c. data files, including *databases*; and
    d. other *software* files needed to install, operate, and *test* the *software* on its *target computer system(s)*.
10. The *developer* **shall** *participate* in automating the software-hardware item integration *test cases*, *test procedures*, test drivers, test scripts, and test data to the extent feasible.

11. The *developer* **shall** *participate* in recording software-hardware item I&T preparation results.
12. The *developer* **shall** *record* software-related software-hardware item I&T preparation results in appropriate *SDFs*.

5.10.3 Performing Software-Hardware Item Integration and Testing

1. The *developer* **shall** integrate the *software items* and *hardware items* in accordance with the software-hardware item integration sequence recorded in the Software Master Build Plan (SMBP) (see Section 5.1.2).
2. The *developer* **shall** participate in performing *testing* of the integrated *software* and *hardware items* in accordance with the *test cases* and *test procedures* prepared according to Section 5.10.2.
3. For all software-hardware item I&T performed, including initial *testing*, *regression testing*, and retesting, the *developer* **shall** *participate* in *recording*:
   a. a complete software-hardware item I&T test log of the software-hardware I&T as the integration and *testing* proceeds;
   b. in this test log, as a minimum, the test log information specified in Appendix F, Section F.2 for software-hardware item I&T;
   c. in this test log all *test incidents* found during software-hardware item I&T, whether or not they are resolved during this activity;
   d. in this test log all instances, if any, of *test incidents* with the same symptoms, whether or not they are resolved during this activity;
   e. in this test log references to all *discrepancy and change reports*, whether or not they are resolved during this activity.
4. The *developer* **shall** *participate* in repeating the software-hardware I&T testing in accordance with Section 5.10.4 (analyzing and *recording*) and Section 5.10.6 (retesting) until all *test cases* and *test procedures* have been performed successfully, i.e., with actual results matching *expected results*.

5.10.4 Analyzing and Recording Software-Hardware Item Integration and Test Results

1. For all software-hardware item I&T performed, including initial *testing*, *regression testing*, and retesting, the *developer* **shall**:
   a. *participate* in analyzing the software-hardware item I&T results;
   b. *participate* in *recording* in *discrepancy and change reports* all *discrepancies* found during software-hardware item I&T, whether or not they are resolved during this activity;
   c. *participate* in *recording* in each *discrepancy and change report,* as a *minimum, the* information specified in Appendix C, Section C.2 for software-hardware item I&T;
   d. *participate* in *recording* the software-hardware item I&T results;
   e. *record* the software-related software-hardware item I&T results in the appropriate *SDFs*;
   f. *participate* in *recording* the software-hardware item I&T analysis results; and
   g. *record* the software-related software-hardware item I&T analysis results in the appropriate *SDFs*.

5.10.5 Software-Hardware Item Integration Regression Testing

1. The *developer* **shall** *participate* in defining a software-hardware item I&T *regression test suite*, including:
   a. instructions for preparing the test environment;
   b. *test cases* for all *verification methods* used for *regression testing* of software-hardware I&T;

c. *test procedures*;
d. test drivers or test scripts, or both; and
e. test data, including test *databases*.

2. The *developer* **shall** *participate* in updating the software-hardware item I&T *regression test suite* to reflect new and changed *requirements*, including software interface *requirements*, and *design*.
3. The *developer* **shall** *record* the software-related software-hardware item I&T *regression test suite* in the appropriate *SDFs*.
4. The *developer* **shall** *participate* in executing the software-hardware item I&T *regression test suite* in accordance with Section 5.10.3 (performing) and Section 5.10.6 (retesting) after any changes, i.e., additions, deletions, and modifications, to:
   a. any previously tested *software*,
   b. any *reusable software* included or integrated with the *software* and *hardware items*,
   c. any other *software,* including test *software* and other *software items,* executing on the *target computer system(s)* in addition to the *software item* under *test,*
   d. the *target computer system(s)* or their configuration(s), or
   e. any previously *tested operational hardware* that interfaces with the *software*, or
   f. the software-hardware item I&T test environment.
5. The *developer* **shall** *participate* in executing the software-hardware item I&T *regression test suite* after any other *software* or *hardware items* have been added to the previously integrated and *tested software* and *hardware items*.
6. The software-hardware item I&T *regression test suite* **shall** be executed after the initial loading of the operational data, including, but not limited to:
   a. flight constants;
   b. ground constants;
   c. *databases*;
   d. stored procedures; and
   e. stored code.
7. The *software-hardware item* I&T *regression test suite* **shall** be executed after loading any changes to the operational data.
8. At the culmination of any *build* that is to be delivered for integration at a higher level or formally delivered to the *acquirer*, the *developer* **shall** *participate* in executing the software-hardware item I&T *regression test suite* to *demonstrate* that any changes, i.e., additions, deletions, and modifications, to the *software* or hardware in that *build* have not affected any *requirements* verified in previous *builds*.
9. The *developer* **shall** *participate* in automating the software-hardware item I&T *regression test suite* to the extent feasible.

Note: See Section 5.10.4 for the *requirements* for analyzing and *recording* the software-hardware item I&T activities and results.

5.10.6 Revising and Retesting Software-Hardware Item Integration

1. Based on the results *of software-hardware item* I&T, including initial *testing*, *regression testing,* and retesting, the *developer* **shall** make the necessary revisions to the *software*.
2. Based on the results of software-hardware item I&T, including initial *testing*, *regression testing,* and retesting, the *developer* **shall** *participate* in making necessary revisions to the:
   a. instructions for preparing the test environment;
   b. *test cases* for all *verification methods* used for software-hardware I&T *retesting*;
   c. test *procedures*;
   d. test drivers or test scripts, or both;

e. test data, including test *databases*;
f. *regression test suite*; and
g. test environment.

3. The *developer* **shall** *participate* in *recording* the software-hardware item I&T revisions.
4. The *developer* **shall** update the *SDFs* to reflect the software-related *software-hardware item* I&T revisions.
5. The *developer* **shall** update other software *products* to reflect the software-hardware item I&T revisions.
6. The *developer* **shall** *participate* in retesting the integrated *software* and *hardware items*:
   a. in accordance with Section 5.10.3 (performing) and Section 5.10.4 (analyzing and *recording*); and
   b. in accordance with the *applicable test cases* and *test procedures* prepared according to Section 5.10.2 (preparing), Section 5.10.5 (*regression*), and Section 5.10.6 (retesting).

Note: See Section 5.10.4 for the *requirements* for analyzing and *recording* the software-hardware item I&T activities and results.

5.11 System Qualification Testing

This section specifies the software-related developer *requirements* for system *qualification testing.* System *qualification testing* is performed to verify that system *requirements* have been met. System *qualification testing* can also be performed to *demonstrate* to the *acquirer* or other stakeholders that system *requirements* have been met. System *qualification testing* in this section is interpreted to mean the *verification* of all levels of *requirements* higher in the *specification tree* than the software *requirements*. It covers *requirements* in the *system specification*, the *subsystem specifications,* if *applicable*, and all other levels of *requirements* between the *system* and *subsystem specifications* and the software requirements *specifications* in the *specification tree* (e.g., element *specifications*, segment *specifications*), including interface *requirements* at all of these levels. This system *qualification testing* contrasts with *developer-internal system integration testing*, performed as the final stage of software-hardware item integration and *testing*.

The term "system *qualification testing*" refers to the activity of verifying that the system *requirements*, including the system interface *requirements*, have been met. System *qualification testing* is an iterative process accomplished for the *system* and includes preparing for *testing* the *system*, dry running the system *qualification test cases*, *testing* the *system*, analyzing and *recording* the test results, fixing problems in the *system* or test preparation *products* (e.g., test data, *test procedures*), and retesting until the system *qualification test cases*, including all *nominal* and *off-nominal test cases*, all execute successfully, i.e., with actual results matching *expected results*. *Requirements* are also included in this section for *regression testing* the *system* if changes (e.g., to the *software*, *target computer system(s)*, other hardware, or environment) are made after the *system* has successfully completed system *qualification testing* in order to determine whether the changes adversely impact the previously verified system *requirements* or system *interface requirements*.

If a *system* is developed in multiple *builds*, system *qualification testing* will not be completed until the final *build*. System *qualification testing* for each *build* is interpreted to mean planning and performing *tests* of the current *build* of the *system* to ensure that the system *requirements* to be implemented in that *build* have been met.

The use of the words "*test*" or "*testing*" in this section is distinct from the *verification method* of Test. The activity of system *qualification testing* can require the use of all *verification methods,* i.e., Inspection (I), Analysis (A), Demonstration (D), and Test (T).

See Section 1.2.5.2 for interpretation of "participate."

5.11.1 Independence in System Qualification Testing

1. The individual(s) responsible for fulfilling the *requirements* in this section **shall** be different individual(s) than those who performed detailed *design* or implementation of the *software* in the *system*.

5.11.2 Testing on the Target Computer System(s)

See the definition of *target computer system* in Section 3.1.

1. System *qualification testing* **shall** be performed with the following in their operational configurations:
   a. *software items* that have successfully passed *software item qualification test;*
   b. *target computer system(s)*; and
   c. *operational hardware* that interfaces with the *software*.
2. All software-related system *qualification testing* **shall** be conducted under conditions representative of those that the *software* will encounter in the operational environment (e.g., operational data constants, operational input and output data rates, operational scenarios).
3. The software-related system *qualification testing* **shall** use actual *interfaces* whenever possible.
4. If using actual *interfaces* is not possible for software-related system *qualification testing*, then validated *high-fidelity simulations* of the *interfaces* **shall** be used.
   Note: See Section 5.2.2 for *validation requirements* for simulations, simulators, and other *software* used for *verification* of *requirements*.
5. All software-related system *qualification testing* **shall** be performed with the entire *software item* installed in the *target computer system(s)* for all *software items* included in the system *test*.
   Note: For *systems* or *software* developed in multiple *builds*, this *requirement* might not be met until the final *build*.
6. The *target computer system(s)* **shall** be in the operational software configuration, including all *software* executing on the *target computer system(s)* (e.g., operating system(s), *COTS software* and any other *reusable software*, and all *software items*).
7. The following **shall** be documented in the system test plan for software-related system *qualification testing*:
   a. the configuration of all *software,* including *test software,* on the *target computer system(s)*;
   b. the *target computer system(s)* and their configuration(s);
   c. the *operational hardware* that *interfaces* with the *software;*
   d. the conditions representing the operational environment (e.g., operational data constants, operational input and output data rates, operational scenarios).

5.11.3 Preparing for System Qualification Testing

1. The *developer* **shall** *participate* in developing the following test preparation *products* for conducting software-related system *qualification testing*:
   a. instructions for preparing the test environment;
   b. *test cases* for all *verification methods* used for system *qualification testing*;
   c. *test procedures*;
   d. test drivers or test scripts, or both; and
   e. test data, including test *databases*.
   Note: See Section 4.2.3.3 for traceability *requirements* for system *qualification testing*.
2. These software-related system *qualification test* preparation *products* **shall** be in accordance with the system test plan (see Section 5.1.3).
3. The *developer* **shall** generate and prepare the *software* from the controlled configuration management system for the system *qualification test* environment, including:

a. executable *software*;
b. procedures, if any;
c. data files, including *databases*; and
d. other *software* files needed to install, operate, and test the *software* on its *target computer system(s)*.

4. The *developer* **shall** verify the configuration of the *software*, including:
   a. verifying that the *software* was generated following the configuration management procedures,
   b. verifying that the software checksums match the configuration management checksums, and
   c. verifying that the build identifier of the *software* under *test* is the same as the build identifier for the *software* generated from the controlled configuration management system if a software checksum is not available.
5. The *developer* **shall** participate in automating the software-related system qualification *test cases*, *test procedures*, test drivers, test scripts, and test data to the extent feasible.
6. The *developer* **shall** *participate* in *recording* software-related system qualification *testing* preparation results.
7. The *developer* **shall** *record* the software-related system qualification testing preparation results in the appropriate *SDFs*.

5.11.4 Dry Run of System Qualification Testing

1. The *developer* **shall** participate in dry running all of the software-related system *qualification test cases* successfully, i.e., with actual results matching *expected results,* using the versions of the *software items* undergoing system *qualification testing* before performing:
   a. system *qualification test* execution, according to Section 5.11.5,
   b. *regression testing*, according to Section 5.11.7, and
   c. any retesting, according to Section 5.11.8.

5.11.5 Performing System Qualification Testing

Note: The activities in this subsection are sometimes called “formal execution” or “run for record.”

1. The *developer* **shall** *participate* in performing the software-related system *qualification testing* in accordance with:
   a. the system *qualification test* plan prepared according to Section 5.1.3, and
   b. the system *qualification test cases* and *test procedures* prepared according to Section 5.11.3.
2. The *developer* **shall** *participate* in *recording* corrections to software-related *test procedure* steps as *redlines* in the *test procedure*.
3. As *testing* proceeds, the *developer* **shall** *participate* in *recording* the software-related system *qualification testing* results as annotations to the *test procedures*, including:
   a. the results of each *test procedure* step,
   b. all differences found between *documented test procedure* steps and actual *test procedure* steps as executed, and
   c. all differences found between the *expected results documented* in the *test procedure* and the actual results as executed.
4. For all software-related system *qualification testing* performed, including all dry runs, initial system *qualification test* execution, *regression testing*, and retesting, the *developer* **shall** *participate* in *recording*:
   a. a complete system *qualification* test log of all system *qualification testing*;

b. in this test log, as a minimum, the test log information specified in Appendix F, Section F.2 for system *qualification testing;*
c. in this test log all *test interruptions* during system *qualification testing*;
d. in this test log all *test incidents* found during system *qualification testing*, whether or not they are resolved during this activity;
e. in this test log all instances, if any, of *test incidents* with the same symptoms, whether or not they are resolved during this activity; and
f. in this test log references to all *discrepancy and change reports*, whether or not they are resolved.

5. The *developer* **shall** *participate* in repeating the software-related system *qualification testing* in accordance with Section 5.11.6 (analyzing and *recording*) and Section 5.11.8 (retesting) until all software-related *test cases* and *test procedures* have been performed successfully, i.e., with actual results matching *expected results*.

5.11.6 Analyzing and Recording System Qualification Test Results

1. For all software-related system *qualification testing* performed, including all dry runs, initial system *qualification test* execution, *regression testing*, and retesting, the *developer* **shall**:
   a. *record* the software-related results of system *qualification testing* in the appropriate *SDFs*;
   b. *participate* in analyzing the software-related system *qualification testing* results;
   c. *participate* in *recording* in *discrepancy and change reports* all *discrepancies* found during system *qualification testing* that are potentially software-related, whether or not they are resolved during this activity;
   d. *participate* in *recording* in *discrepancy and change reports*, as a minimum, the information specified in Appendix C, Section C.2 for system *qualification testing*;
      Note: For the *discrepancies* that are clearly hardware-only problems, some of the information specified in Appendix C, Section C.2 might not apply.
   e. *participate* in *recording* the software-related system *qualification testing* analysis results; and
   f. *record* the software-related system *qualification testing* analysis results in the appropriate *SDFs*.

5.11.7 System Qualification Regression Testing

1. The *developer* **shall** *participate* in defining a software-related system qualification *regression test suite,* including:
   a. instructions for preparing the test environment;
   b. *test cases* for all *verification methods* used for system qualification *regression testing*;
   c. *test procedures*;
   d. test drivers or test scripts, or both; and
   e. test data, including test *databases*.
2. The *developer* **shall** *participate* in updating the software-related system *qualification regression test suite* to reflect new and changed *requirements,* including interface *requirements,* and *design*.
3. The *developer* **shall** *participate* in automating the software-related system qualification *regression test suite* to the extent feasible.
4. The *developer* **shall** *record* the software-related system qualification *regression test suite* in the appropriate *SDFs*.
5. The *developer* **shall** *participate* in executing the software-related system qualification *regression test suite* in accordance with Section 5.11.5 (performing) and Section 5.11.8 (retesting) after any changes, i.e., additions, deletions, and modifications, to:
   a. any *software* that previously underwent system *qualification testing*;

b. any *reusable software* included or integrated with the *system*;
c. any other *software,* including test *software,* executing on the *target computer system(s)* in addition to the *software items* under *test*;
d. the *target computer system(s)* or their configuration(s);
e. any *operational hardware* that interfaces with the *software;* or
f. the configuration(s) of the hardware under *test*.

6. The *test cases* from the software-related system qualification *regression test suite* **shall** be executed after the initial loading of the operational data, including, but not limited to:
   a. flight constants;
   b. ground constants;
   c. *databases*;
   d. stored procedures; and
   e. stored code.
7. The *test cases* from the software-related system qualification *regression test suite* **shall** be executed after loading any changes to the operational data.

Note: See Section 5.11.6 for the *requirements* for analyzing and *recording* the system *qualification testing* activities and results.

5.11.8 Revising and Retesting the System

1. Based on the results of software-related system *qualification testing,* including dry runs, initial system *qualification test* execution, *regression testing*, and retesting, the *developer* **shall** make necessary revisions to the *software*.
2. Based on the results of software-related system *qualification testing,* including dry runs, initial *qualification test* execution, *regression testing*, and retesting, the *developer* **shall** *participate* in making necessary revisions to the:
   a. software-related *test cases* for all *verification methods* used for system *qualification* retesting,
   b. software-related *test procedures*;
   c. test drivers or test scripts, or both;
   d. test data, including test *databases*; and
   e. software-related *regression test suite*.
3. The *developer* **shall** update the *SDFs* to reflect the software-related system qualification testing revisions.
4. The *developer* **shall** update other software *products* to reflect the system qualification testing revisions.
5. The *developer* **shall** *participate* in software-related system *qualification retesting*:
   a. in accordance with Section 5.11.5 (performing) and Section 5.11.6 (analyzing and *recording*); and
   b. in accordance with the *applicable test cases and procedures* prepared according to Section 5.11.3 (preparing), Section 5.11.7 (regression), and Section 5.11.8 (retesting).

Note: See Section 5.11.6 for the *requirements* for analyzing and *recording* the system *qualification testing* activities and results.

5.12 Preparing for Software Transition to Operations

This section specifies the developer *requirements* for *software* use, including *transition* to operations.
Note 1: If *software* is developed in multiple *builds*, the developer's *build* planning identifies for each *build* what *software*, if any, is to be fielded, i.e., distributed, to *user sites* and the extent of fielding (for example, full fielding or fielding to selected evaluators only). Preparing for *software* use in each *build* is interpreted to include those activities necessary to carry out the fielding plans for that *build*.

Note 2: This standard does not cover hardware installation.
Note 3: See Section 1.2.5.7 and 1.2.5.8 for definitions of *user* and *user site*, respectively.
Note 4: Different *user sites* may require different configuration parameters and different configurations of the *software*, some unique to the specific *user site* or category of *user site*.

5.12.1 Preparing the Executable Software

1. The *developer* **shall** generate and prepare the executable *software* for each *user site.*
2. Except for *COTS* executable *software*, the *developer* **shall** generate and prepare the executable *software* for the *user site(s)* from the configuration managed versions of *source files* for delivery for those *user site(s)*.

   Note: Some of the *COTS software* might be generated and prepared using the built-in configuration, system administrator, user default, and other options, settings, and preferences, e.g., user privileges. Settings for different users might vary depending upon their roles.
3. The *developer* **shall** prepare any additional files, e.g., batch files, command files, configuration files, data files, *databases*, or other files, needed to install or operate the *software* on the *target computer system(s)* for each *user site*.
4. The preparation result **shall** include all *applicable* items in the executable *software* section of the Software Product Specification (SPS) *DID*, as defined in the SDP (see Section 5.1.1).

   Note: See Section 6.2 for the SPS *DID* identifier.

5.12.2 Preparing Version Descriptions for User Sites

1. The *developer* **shall** *identify* and *record* the exact version of *software* prepared for each *user site*.
2. The *developer* **shall** prepare and *record* the *software* installation instructions for each *user site*.
3. The result of preparing the version description information for the *user site(s)* **shall** include all *applicable* items in the Software Version Description (SVD) *DID*, as defined in the SDP (see Section 5.1.1).

   Note: See Section 6.2 for the SVD *DID* identifier.

5.12.3 Preparing User Manuals

This subsection specifies the developer *requirements* for preparing *user* manuals.

Note: Few, if any, *systems* need all of the manuals in this section. The intent is for the *acquirer*, with input from the *users* and *developer*, to determine which manuals are appropriate for a given *system* and to require the development of only those manuals. Commercial or other manuals that contain the required information can be substituted for the manuals specified in this standard. The manuals in this section are normally developed in parallel with the *software development* activities described in Sections 5.1 through 5.11.

1. Preliminary versions of the manuals in this section **shall** be available before the *SIQT* Software Build Test Readiness Review (SBTRR) for use in *software item qualification testing*.

5.12.3.1 Software User Manuals

1. The *developer* **shall** *identify* and *record* information needed by *users* of the *software.*
2. The information needed by *users* **shall** include all *applicable* items in the Software User Manual (SUM) *DID*, as defined in the SDP (see Section 5.1.1)

   Note: See Section 6.2 for the SUM *DID* identifier.

5.12.3.2 Computer Operation Manuals

This subsection only applies to computers without commercial operations manuals or to computers when their commercial operations manuals are inadequate. Examples of *computer hardware* for which this section applies are the processors in special test equipment or flight testbeds.

1. The *developer* **shall** *identify* and *record* the information needed to operate the computers on which the *software* will run.
2. The information needed to operate the computers **shall** include all *applicable* items in the Computer Operation Manual (COM) *DID*, as defined in the SDP (see Section 5.1.1).
   Note: See Section 6.2 for the COM *DID* identifier.

5.12.4 Installation at User Sites

Note: If *software* is developed in multiple *builds*, the developer's *build* planning identifies for each *build* what *software*, if any, to install at each *user site*. Preparing for *software transition* for each *build* is interpreted to include those activities necessary to carry out the *transition* to operations plans for that *build*.

1. The *developer* **shall** install the executable *software* at the *acquirer*-designated *user site(s)* using the installation procedure in the SVD.
   Note: See Section 6.2 for the SVD *DID* identifier.
2. The *developer* **shall** perform the *checkout process* and procedures on the executable *software* and related files at each *acquirer*-designated *user site*.
   Note: *Checkout* can use subsets of the *software item qualification regression test suite*.
3. The *developer* **shall** provide training to the *software users*.

5.13 Preparing for Software Transition to Maintenance

This section specifies the developer *requirements* for preparing for *transition* of *software* to *maintenance*.

Note 1: If *software* is developed in multiple *builds*, the developer's planning identifies for each *build* what *software*, if any, is to be transitioned to the *maintenance organization(s)*. Preparing for *software transition* for each *build* is interpreted to include those activities necessary to carry out the *transition* plans for that *build*.

Note 2: *Software maintenance* might be performed by the same organization(s) that developed the *software* or by different organization(s) (e.g., an *acquirer maintenance organization*, another development contractor, another organization within the company that developed the *software*, or some combination of organizations).

Note 3: There may be one or more designated *maintenance* sites for the *software*. This section addresses transition to all designated *maintenance* sites.

5.13.1 Preparing the Executable Software

1. The *developer* **shall** generate and prepare the executable *software* to be *transitioned* to the *maintenance* site(s).
2. Except for *COTS* executable *software*, the *developer* **shall** generate and prepare the executable *software* from the configuration-managed versions of source files for delivery for the *maintenance* site(s).
   Note: Some of the *COTS software* might be generated and prepared using the built-in configuration, system administrator, user default, and other options, settings, and preferences, e.g., user privileges. Settings for different users might vary depending upon their roles.
3. The *developer* **shall** prepare any additional files, e.g., batch files, command files, configuration files, data files, *databases*, or *other files*, needed to maintain, regenerate, install, and operate the *software* on the *maintenance* computers and *target computer system(s)* for the *maintenance* site(s).
4. The result of preparing the executable *software* **shall** include all *applicable* items in the executable *software* section of the Software Product Specification (SPS) *DID*, as defined in the SDP (see Section 5.1.1).
   Note: See Section 6.2 for the SPS *DID* identifier.

5.13.2 Preparing Source Files

1. The *developer* **shall** prepare the source files to be *transitioned* to the *maintenance* site(s).
2. The *developer* **shall** prepare any additional files, e.g., batch files, command files, configuration files, data files, *databases*, or other files, needed to maintain, regenerate, install, and operate the *software* on the *target computer system(s)* for the *maintenance* site(s).
3. The result of preparing the source files **shall** include all *applicable* items in the source file section of the Software Product Specification (SPS) *DID*, as defined in the SDP (see Section 5.1.1).
   Note 1: See Section 6.2 for the SPS *DID* identifier.
   Note 2: See Section 4.2.3.4 for traceability requirements for the source files.

5.13.3 Preparing Version Descriptions for the Maintenance Site(s)

1. The *developer* **shall** *identify* and *record* the exact version of *software* prepared for the *maintenance* site(s).
2. The *developer* **shall** prepare and *record* the software installation instructions for the *maintenance* site(s).
3. The result of preparing the version description information for the *maintenance* site(s) **shall** include all *applicable* items in the SVD *DID*, as defined in the SDP (see Section 5.1.1).
   Note: See Section 6.2 for the SVD *DID* identifier.

5.13.4 Preparing the 'As Built' Software Architecture, Design, and Related Information

1. The *developer* **shall** update the overall software *architecture* in the Software Architecture Description (SAD) to match the "as built" *software*.
   Note: See Section 6.2 for the SAD *DID* identifier.
2. The *developer* **shall** update the *software item architecture* of each *software item* in the SAD to match the "as built" *software*.
3. The *developer* **shall** update the *design* descriptions of each *software item* in the SPS to match the "as built" *software*.
4. The *developer* **shall** *define* and *record*:
   a. the methods to be used to verify copies of the *software*,
   b. other information needed to *maintain* the *software*, and
   c. the measured *computer hardware* resource utilization for the *software item*.
5. The result of preparing the "as built" *software item design* and related information **shall** include all *applicable* items in the Software Product Specification (SPS) *DID*, as defined in the SDP (see Section 5.1.1):
   Note 1: See Section 6.2 for the SPS *DID* identifier.
   Note 2: Requirements for the executable *software* and source files sections of the SPS *DID* are addressed in Section 5.13.1 and Section 5.13.2.
   Note 3: See Section 4.2.3.4 for traceability requirements for the SPS.

5.13.5 Updating the System/Subsystem Design Description

1. The *developer* **shall** *participate* in updating the *system* and *subsystem* design description to match the "as built" *system*.
2. The result of updating the *system*/*subsystem* design description **shall** include all *applicable* items in the System/Subsystem Design Description (SSDD) *DID*, as defined in the SDP (see Section 5.1.1).
   Note 1: See Section 6.2 for the SSDD *DID* identifier.
   Note 2: See Section 4.2.3.1 for traceability requirements for the SSDD.

5.13.6 Updating the Software Requirements [5]

1. The *developer* **shall** update the software *requirements* and software interface *requirements* for each *software item* to match the "as built" *system*.
2. The result of updating the software *requirements* **shall** include all *applicable* items in the Software Requirements Specification (SRS) *DID* as defined in the SDP (see Section 5.1.1).
3. The result of updating the software interface *requirements* **shall** include all *applicable* items in the Interface Requirements Specification (IRS) *DID* as defined in the SDP (see Section 5.1.1).

Note 1: See Section 6.2 for the SRS and IRS *DID* identifiers.
Note 2: See Section 4.2.3.1 for traceability *requirements* for software *requirements* and software interface *requirements*.

5.13.7 Updating the System Requirements [6]

1. The *developer* **shall** *participate* in updating the *system requirements* to match the "as built" *system*.
2. The *developer* **shall** *participate* in updating the *system* interface *requirements* to match the "as built" *system*.
3. The result of updating the *system requirements* **shall** include all *applicable* items in the System/Subsystem Specification (SSS) *DID*, as defined in the SDP (see Section 5.1.1).
4. The result of updating the *system* interface *requirements* **shall** include all *applicable* items in the Interface Requirements Specification (IRS) *DID*, as defined in the SDP (see Section 5.1.1).

Note 1: See Section 6.2 for the SSS and IRS *DID* identifiers.
Note 2: An *interface* could be specified in *system* or *subsystem specifications*, as *applicable*, or could be specified in *interface requirements specifications* or *interface* control *documents* (ICDs).
Note 3: If a *system* consists of *subsystems*, the activity in Section 5.13.7 is intended to be performed also for *subsystems* at all levels.
Note 4: See Section 4.2.3.1 for traceability *requirements* for *system requirements* and interface *requirements*.

5.13.8 Preparing Maintenance Manuals

This section specifies the developer *requirements* for preparing maintenance manuals.
Note: Few, if any, *systems* will need the manuals discussed in this section. The intent is for the *acquirer*, maintainer, and *developer* to determine which manuals are appropriate for a given *system* and to require the development of only those manuals. Commercial or other manuals that contain the required information can be substituted for the manuals specified in this standard. The manuals in this section supplement the SSDD, the SAD, and the SPSs, which serve as the primary sources of information for *software maintenance*. The *user* manuals cited in Section 5.12.3 are also useful to maintenance personnel.

5.13.8.1 Computer Programming Manuals

This subsection applies only to newly developed *computer hardware* that does not have commercial programming manuals available or to *computer hardware* for which the commercial programming manuals are inadequate.

1. The *developer* **shall** *identify* and *record* information needed to program the computers on which the *software* was developed or on which it will run.
2. The information for programming the computers **shall** include all *applicable* items in the Computer Programming Manual (CPM) *DID*, as defined in the SDP (see Section 5.1.1).
   Note: See Section 6.2 for the CPM *DID* identifier.

---

[5] This subsection is based on information from Section 5.13.6 of (EIA/IEEE J-016).

[6] This subsection is based on information from Section 5.13.7 of (EIA/IEEE J-016).

5.13.8.2 Firmware Support Manuals

1. The *developer* **shall** *identify* and *record* information needed to program and reprogram any *firmware* devices in which the *software* will be installed.
2. The information for programming and reprogramming the *firmware* devices **shall** include all *applicable* items in the Firmware Support Manual (FSM) *DID*, as defined in the SDP (see Section 5.1.1).

   Note: See Section 6.2 for the FSM *DID* identifier.

5.13.9 Transition to the Designated Maintenance Site(s)

1. The *developer* **shall** install the *software* transitioning to *maintenance* in the designated software maintenance site(s).
2. The *developer* **shall** perform the *checkout process* and procedures on the *software* transitioning to *maintenance* at each designated software maintenance site.

   Note: *Checkout* can use subsets of the *software item qualification regression test suite* and other *regression test suites*.
3. The *developer* **shall** *demonstrate* to the *acquirer* that the *software transitioning* to *maintenance* can be regenerated, i.e., compiled, linked, and loaded into an executable *product,* and *maintained* using the hardware and software tools at each designated *maintenance* site.
4. The *developer* **shall** provide training to the designated software maintenance organization(s) as specified in the *contract* and in the software transition plan (see Section 5.1.5).
5. The *developer* **shall** provide other assistance to the designated *software maintenance* organization(s) as specified in the *contract* and in the software transition plan (see Section 5.1.5).

5.14 Software Configuration Management

This section specifies the developer *requirements* for software configuration management.
Note: If a *system* or *software item* is developed in multiple *builds*, the *products* of each *build* might be refinements of, or additions to, *products* of previous *builds*. Software configuration management for each *build* takes place in the context of the *products* and configuration controls in place at the start of the *build*.

5.14.1 Configuration Identification

1. The *developer* **shall** *identify* the entities to be placed under configuration control.
2. The entities to be placed under configuration control **shall** include, as a minimum:
   a. all *products* to be developed or used under the *contract*;
   b. all *products* specified by this standard;
   c. all elements of the *software engineering environment*; and
   d. all elements of the *software integration and qualification test environment*.
3. The *developer* **shall** assign a project-unique identifier to each *software item* to be placed under configuration control.
4. The *developer* **shall** assign a project-unique identifier to each additional entity to be placed under configuration control.
5. The identification scheme **shall** be at the level at which entities will be controlled, for example, computer files, electronic media, *documents*, *software units*, *hardware items*, and *software items*.
6. The identification scheme **shall** include the version, revision, and release status of each entity.
7. For each identified entity (e.g., *source code*, *document*, executable code) the *developer* **shall**:
   a. label each entity unambiguously with product identification; and

b. include configuration identification within the entity if the product identification cannot be determined by physical examination.

8. Configuration identification **shall** occur prior to the implementation of change control.

5.14.2 Configuration Control

1. The *developer* **shall** *establish* and implement procedures designating:
   a. the levels of control each identified entity must pass through (for example, author control, project control, *acquirer* control);
   b. when each entity is to be placed under configuration control;
   c. the persons or groups with authority to:
      (1) authorize changes, and
      (2) make changes at each level (for example, the programmer, analyst, software lead, project manager, *acquirer*); and
   d. the steps to be followed to:
      (1) request entry of an entity into configuration control,
      (2) request authorization for changes,
      (3) process change requests,
      (4) assess impact of change requests,
      (5) track changes,
      (6) authorize distribution of changed *products*,
      (7) distribute changed *products*, and
      (8) *maintain* past versions.

   Note 1: The levels of control to be implemented are dependent upon the entity to be placed under configuration control. Thus, an SRS generally passes through author-level control, software configuration management level control, and project-level control. Software code, on the other hand, generally has more levels of control, for example: individual author or engineer, software integration (e.g., team leader level), software *build* integration, *software item qualification*, *subsystem*, and *system* control. The SDP defines the levels of control to be used for each entity to be placed under configuration control, in addition to the roles, responsibilities and procedures for each level.

   Note 2: The configuration control levels usually include one or more levels of configuration control boards (CCBs).

   Note 3: See Section 5.17 for more information on *discrepancy and change reports*.

2. Changes that affect an entity already under *acquirer* control **shall** be proposed to the *acquirer* in accordance with *contractually* established forms and procedures, if any.
3. The *developer* **shall** *establish* and perform procedures for checking out and checking in entities from the configuration controlled library that ensure that:
   a. conflicting or simultaneous updates do not occur, and
   b. all changes are reviewed for impacts (e.g., correctness, safety, security) before being checked in.
4. The *developer* **shall** *establish* and perform archive and retrieval procedures to ensure that all past versions of all entities that have been placed under any level of configuration control above the individual author or engineer level can be retrieved only from the configuration controlled library.

   Note: The goals of the archive and retrieval procedures are to ensure that:
   a. only authorized *software* is used, and
   b. the authorized *software* is archived and retrievable.
5. The *developer* **shall** control and *maintain* configuration entities throughout the system development lifecycle.
6. The *developer* **shall** *establish* and perform access control procedures that restrict individuals to the minimum set of configuration management functions and configuration entities needed to

perform their assigned duties (e.g., to access, *establish*, or change configuration controlled entities).

5.14.3 Configuration Status Accounting

1. The *developer* **shall** prepare and *maintain* records of the configuration status of all entities that have been placed under any level of configuration control above the individual author or engineer level.
2. The configuration status records **shall** include, as *applicable* for each entity:
   a. the current version, revision, and release of the entity,
   b. a record of changes to the entity since being placed under any level of configuration control above the individual author or engineer level, and
   c. the status of *discrepancy and change reports (DCRs)* affecting the entity.
3. The *developer* **shall** provide a *build* report for each *build*, including, as a minimum:
   a. the version of each configuration entity included,
   b. the *DCRs* closed with the *build*,
   c. the *DCRs* remaining open, and
   d. the changes, i.e., additions, deletions, and modifications, made.

   Note: The Software Version Description (SVD) *DID* has additional content that is useful for a *build*. See Section 6.2 for the SVD *DID* identifier.
4. The configuration status records **shall** be *maintained* throughout the system development lifecycle.

Note: The degree of formality of the configuration status accounting can differ at different levels of configuration control.

5.14.4 Configuration Audits [7]

1. The *developer* **shall** periodically conduct configuration audits at the times specified in the SDP of all entities that have been placed under any level of configuration control above the individual author or engineer level.
2. The configuration audits **shall** determine whether each entity incorporates all approved changes scheduled for inclusion at the time of the audit.
   Note: The approval of changes is usually performed by a software configuration control board.
3. The configuration audits for each entity **shall** determine whether the entity incorporates any unapproved changes.
4. Any configuration audit exception findings **shall** be documented in configuration management noncompliance reports that are then entered into the corrective action system. (See Section 5.17.)

Note: The degree of formality and frequency of the configuration audits can differ at different levels of configuration control.

5.14.5 Packaging, Storage, Handling, and Delivery

1. The *developer* **shall** *establish*, *record*, and implement procedures for the packaging, storage, handling, and delivery of deliverable software *products*.
2. The *developer* **shall** *maintain* master copies of delivered software *products* throughout the system development lifecycle.
3. Throughout the system development lifecycle, the *developer* **shall** *maintain* master copies of the source files needed to generate the delivered executable *software*.
4. The *developer* **shall** *establish* procedures to *maintain* the integrity of the stored data as required by the contract, regardless of medium of storage throughout the system development lifecycle.
   Note: Techniques for maintaining the integrity of stored data include:

[7] This subsection is based on information from Section 5.14.4 of (EIA/IEEE J-016).

a. selecting storage media that minimize regeneration errors or deterioration;
b. exercising and refreshing archived data at a frequency compatible with the storage life of the medium; and
c. storing duplicate copies in physically separate archives that minimize the risk of loss in the event of a disaster.

5. The *developer* **shall** *establish* the release authorization procedures, including approval authority, for releasing configuration items and other software *products* for:
   a. higher levels of integration,
   b. installation at *user site(s)*, and
   c. delivery to the *acquirer*.

5.14.6 Baselines

1. The *developer* **shall** *establish* and *maintain* software *baselines* for internal use.
2. The *developer* **shall** *establish* and *maintain* a software *baseline* for each delivery to higher levels of integration, e.g., *subsystem*, *system*.
3. The *developer* **shall** *establish* and *maintain* a software *baseline* for each delivery:
   a. to higher levels of integration,
   b. for installation in operations, and
   c. to the *acquirer*.
4. The *developer* **shall** *establish* and *maintain* an overall software architecture *baseline.*
5. The *developer* **shall** *establish* and *maintain* a software requirements *baseline* for each *software item.*
6. The *developer* **shall** *establish* and *maintain* a software architecture *baseline* for each *software item.*
7. The *developer* **shall** *establish* and *maintain* a software design *baseline* for each *software item.*
8. The *developer* **shall** *establish* and *maintain* a software item *baseline* for each *software item* for each *build*, including, as a minimum, a consistent set of the following configuration controlled items as *applicable* to the *build* and *software item*:
   a. software item *requirements,* including software interface *requirements*;
   b. software item *architecture*;
   c. software item *design,* interface *design,* and database *design*;
   d. software item unit *test cases* and results;
   e. software item *source code* files and other files necessary for generating the executable code and data files;
   f. software item executable files and data files;
   g. software item unit integration *test cases, test procedures,* and test results;
   h. software item qualification *test cases, test procedures*, and test results;
   i. software item version description, and installation and *user documentation*;
   j. software item maintenance *documentation*;
   k. software item "as built" *documentation*; and
   l. lists of requested and approved liens, waivers, and deviations for the *software item*;

   Note: For software developed in *builds*, this *requirement* will be performed on a *build*-by-*build* basis.

5.15 Software Peer Reviews and Product Evaluations

This section specifies the developer *requirements* for peer reviews and product *evaluations*.

5.15.1 Software Peer Reviews

This subsection specifies the developer *requirements* for performing peer reviews of software *work products*.

1. The *developer* **shall** perform peer reviews on all *work products* for the *products* listed in Appendix D Table D.3-1.

Note: Planning for peer reviews of software *work products* is part of software development planning (see Section 5.1.1) and is *recorded* in the SDP.

5.15.1.1 Plan for Software Peer Reviews

This subsection addresses planning for a group of peer reviews.

1. The *developer* **shall** plan for the peer reviews on the software *work products* as specified in the SDP.
2. The *developer* **shall** *define* and *record* what type of peer review to conduct on which types of software *work products*.
   Note: The type of *software* and *work product* influences the type of peer review required, e.g., the *developer* could require inspections for requirements peer reviews, inspections for *design* and code peer reviews of anomaly detection and correction units, and walkthroughs for nonmission-critical code.
3. The *developer* **shall** *define* and *record* which roles are required to participate in which types of peer reviews.
   Note: Required roles might include, e.g., systems engineers, *user* representatives, and other stakeholders for software *requirements*.
4. The *developer* **shall** *define* and *record* which roles must attend peer reviews for which types of software *work products*.
5. The *developer* **shall** *define* and *record* entry and exit checklists for each type of *work product*.
6. The *developer* **shall** *define* and *record* maximum sizes for each type of *work product* to enable the peer review coordinator to divide the work products into pieces for multiple peer review sessions.
7. The *developer* **shall** *record* the peer review planning for each type of *work product* in the SDP.

Note: See Appendix D.3 for the *requirements* for *evaluation* criteria for *work products* and *products*.

5.15.1.2 Prepare for an Individual Peer Review

This subsection addresses preparation for an individual peer review.

1. For each peer review, the *developer* **shall** identify key reviewers who are required to *participate* in the peer review.
   Note: Key reviewers can be identified by name for specific *work products*.
2. For each peer review, the *developer* **shall** prepare for the type of peer review specified in the SDP for the software *work product*.
3. For each peer review, the *developer* **shall** *demonstrate* that the software *work product* satisfies the peer review entry criteria prior to distribution of peer review materials.
4. For each peer review, each reviewer **shall** prepare by reviewing the software *work product* prior to *participating* in the peer review.

Note: See Appendix D.3 for the *requirements* for *evaluation* criteria for *work products* and *products*.

5.15.1.3 Conduct Peer Reviews

1. The *developer* **shall** perform peer reviews on the software *work products* as specified in the SDP, ensuring that all entry criteria are satisfied, including product size, adequate preparation time by each participant, and participation by all required participants.

2. For each peer review, the *developer* **shall** *identify* and *record discrepancy and change reports*, action items, and *issues* about the software *work product*.
   Note: See Appendix C.2 for *discrepancy and change report* definitions (C.2.1) and *requirements* (C.2.2).
3. For each peer review, the *developer* **shall** collect and *record* the peer review data, including the items listed in Section 5.15.1.4.
4. For each peer review, the *developer* **shall** *demonstrate* that the exit criteria for the peer review are satisfied.

5.15.1.4 Analyze and Report Peer Review Data

1. The *developer* **shall** analyze and report summary data about the peer reviews, including:
   a. preparation time;
   b. possible defects and issues found during preparation;
   c. length of peer review (all hours by all participants after preparation);
   d. defects found during the peer review;
   e. number of participants;
   f. roles of participants;
   g. conduct;
   h. results, including *discrepancy and change reports,* action items, and *issues;* and
   i. trends (e.g., the most frequent types of *discrepancies*).

5.15.2 Product Evaluations

This section specifies the developer *requirements* for performing product *evaluations* of the *products* generated in carrying out the *requirements* of this standard.
Note 1: If a *system* or *software item* is developed in multiple *builds*, the *products* of each *build* are evaluated in the context of the objectives established for that *build*. A *product* that meets those objectives can be considered satisfactory even though it is missing information designated for development in later *builds*.
Note 2: Planning for product *evaluations* is part of software development planning (see Section 5.1.1) and is *recorded* in the SDP.

5.15.2.1 In-Process and Final Product Evaluations

1. The *developer* **shall** perform in-process product *evaluations* of the *products* specified in Appendix D Table D.3-1.
2. The *developer* **shall** perform a final product *evaluation* of the completed *products* specified in Appendix D Table D.3-1.
   Note: If a *system* or *software item* is developed in *builds*, the final product *evaluation* is performed on a *build*-by-*build* basis as that *product* is completed in the context of the objectives for that *build*.
3. For each *product* specified in Appendix D Table D.3-1, the *developer* **shall** perform in-process *evaluations* and final *evaluations* using, as a minimum, the product *evaluation* criteria specified in Appendix D Table D.3-1 for that *product*.
   Note: The definitions for the *evaluation* criteria are specified in Appendix D.2.
4. The developer **shall** *document* all *discrepancies* found during the product *evaluations* in *DCRs*.
5. The developer **shall** manage the *DCRs* from the product *evaluations* using the corrective action system.

5.15.2.2 Product Evaluation Records

1. The *developer* **shall** prepare and *maintain* records of each product *evaluation*.
2. The product *evaluation* records **shall** contain, as a minimum, the following items:
   a. date of review;

b. *product* reviewed;
c. version of *product* reviewed;
d. size of *product* (e.g., pages, number of *requirements)*;
e. evaluation criteria used;
f. participants by role and name;
g. preparation time by each participant;
h. length in time of review;
i. comment review matrix containing comments from all participants with dispositions for each;
j. *discrepancy and change reports* generated;
k. action items generated; and
l. *issues* identified.

3. The product evaluation records **shall** be *maintained* throughout the system development lifecycle.
4. *Discrepancies* in software *products* under any level of configuration control above the individual author or engineer level **shall** be managed as specified in Section 5.17, Corrective action.

5.15.2.3 Independence in Product Evaluation

1. The individuals responsible for evaluating a *product* **shall** be different individuals than those who developed the *product*.
   Note: This *requirement* does not preclude the individuals who developed the *product* from taking part in the *evaluation* (for example, as participants in a peer review of the *product*).

5.16 Software Quality Assurance

This section specifies the developer *requirements* for software quality assurance.
Note: If a *system* or *software item* is developed in multiple *builds*, the activities and software *products* of each *build* are evaluated in the context of the objectives established for that *build*. An activity or software *product* that meets those objectives can be considered satisfactory even though it is missing aspects designated for later *builds*. Planning for software quality assurance is included in *software development* planning (see Section 5.1.1) and is *recorded* in the SDP.

5.16.1 Software Quality Assurance Evaluations

1. The *developer* **shall** conduct ongoing *evaluations* at the times specified in the SDP of the *software development processes*, software *products*, *work products*, and software services to assess:
   a. adherence of the designated, performed *processes* to the *applicable* process descriptions, standards, and procedures in accordance with the:
      (1) *contract*, and
      (2) SDP;
   b. adherence of the designated software *products* to the *applicable* process descriptions, standards, and procedures in accordance with the:
      (1) *contract*, and
      (2) SDP;
   c. adherence of the designated *work products* to the *applicable* process descriptions, standards, and procedures in accordance with the:
      (1) *contract*, and
      (2) SDP;
   d. adherence of the designated software services to the *applicable* process descriptions, standards, and procedures in accordance with the:

(1) *contract*, and
(2) SDP;

e. that each software *product* required by this standard and each software *product* required by any other *contract* provisions:
(1) exists and has undergone software peer reviews;
(2) has undergone software product *evaluations*;
(3) has undergone *testing,* for those *products* where *testing* is *applicable*, and
(4) has undergone corrective action for all identified *discrepancies*.

f. continued consistency among all software-related plans, including as a minimum, the Software Development Plan (SDP), Software Test Plan (STP), and Software Master Build Plan (SMBP); and

g. continued consistency with system-level plans, including as a minimum, management plans and system test plans.

2. The *developer* **shall** provide feedback to affected groups on the:
a. evaluation results;
b. status of evaluation issues; and
c. status of *DCRs*.

5.16.2 Software Quality Assurance Records

1. The *developer* **shall** *establish* and *maintain* records of each software quality assurance activity.
2. The software quality assurance activity records **shall** be *maintained* throughout the system development lifecycle.

5.16.3 Independence in Software Quality Assurance

1. The individual(s) responsible for conducting software quality assurance *evaluations* of a given software *product*, *work product*, *process*, or service **shall** be different individual(s) than those:
a. who developed the software *product*, *work product*, *process*, or service, and
b. who are responsible for the software *product*, *work product*, *process*, or service.
2. The individual(s) responsible for assessing compliance with the *contract* and compliance with the *processes* **shall** have the:
a. resources,
b. responsibility,
c. authority, and
d. organizational autonomy necessary to:
(1) permit objective software quality assurance *evaluations*, and
(2) initiate and verify corrective actions.

5.16.4 Software Quality Assurance Noncompliance Issues

1. The *developer* **shall** communicate quality *issues* with the staff and managers.
2. The *developer* **shall** communicate noncompliance *issues* with the staff and managers.
3. The *developer* **shall** resolve quality *issues* with the staff and managers.
4. The *developer* **shall** resolve noncompliance *issues* with the staff and managers.
5. The *developer* **shall** use an established escalation mechanism for the appropriate level of management to resolve the *issues*.
6. The *developer* **shall** track noncompliance *issues* to resolution.
7. Noncompliance *issues* in software *products* or *work products* under any level of configuration control above the individual author or engineer level **shall** be managed as specified in Section 5.17.2, Corrective action system.

5.17 Corrective Action

This section specifies the developer *requirements* for performing corrective action.

5.17.1 Discrepancy and Change Reports

1. The *developer* **shall** establish and *maintain discrepancy and change report (DCR)* procedures that cover:
   a. writing and submitting *DCRs* into the corrective action system,
   b. prompt disposition of *DCRs* (e.g., assessment and assignment), and
   c. providing feedback to affected groups.
2. The *developer* **shall** prepare a *DCR* to describe:
   a. each *discrepancy* or *test incident* detected in software entities under any level of configuration control above the individual author or engineer level,
   b. each change requested in software entities under any level of configuration control above the individual author or engineer level,
   c. each *discrepancy* in activities or *products* required by the *contract*, and
   d. each *discrepancy* in activities or *products* specified in the SDP.

   Note: See Appendix C.2 for *discrepancy and change report* definitions (C.2.1) and *requirements* (C.2.2).
3. The *discrepancy and change reports* **shall** serve as input to the corrective action system.

Note 1: The degree of formality of the *discrepancy and change reports* can differ at different levels of configuration control.

Note 2: *Discrepancy and change reports* are sometimes called problem reports, change requests, trouble reports, test incident reports, issue reports, and other terms.

5.17.2 Corrective Action System

This section specifies the *requirements* for the developer's corrective action system.

1. The *developer* **shall** implement a corrective action system for managing:
   a. each *discrepancy* detected in software entities under any level of configuration control above the individual author or engineer level,
   b. each change requested in software entities under any level of configuration control above the individual author or engineer level,
   c. each *discrepancy* or *issue* in activities or *products* required by the *contract*, and
   d. each *discrepancy* or *issue* in activities or *products* specified in the SDP.
2. The *developer* **shall** *demonstrate* that:
   a. all *discrepancy and change reports* are promptly reported and entered into the corrective action system;
   b. the impacts are promptly evaluated;

      Note: Example impacts that can result include the effect on *products* (e.g., *requirements*, *architecture*, *design*, code, *test cases*), related *products*, cost, schedule, current and future releases, and operations.
   c. disposition (e.g., approved, rejected, deferred) is determined promptly;
   d. feedback and status are provided to affected groups;
   e. action is initiated on each *discrepancy and change report;*
   f. the change is tested or otherwise evaluated to determine:
      (1) whether the change is correctly implemented, and
      (2) whether the *discrepancy* has been fixed without introducing additional *discrepancies*;
   g. resolution is achieved;
   h. status is tracked to closure; and

i. records of the *discrepancy and change reports* are *maintained* throughout the system development lifecycle.

Note: See Appendix C.2 for *discrepancy and change report* definitions (C.2.1) and *requirements* (C.2.2).

3. The *developer* **shall** re-evaluate all *discrepancy and change reports* deferred from previous *builds* and software reviews to determine their current status.
4. The *developer* **shall** perform analysis to detect trends in the *discrepancy and change reports*.
5. The *developer* **shall** perform periodic *evaluations* of corrective actions to determine whether:
   a. *discrepancies* have been resolved,
   b. adverse trends have been reversed, and
   c. changes have been correctly implemented without introducing additional *discrepancies*.
6. The *developer* **shall** specify in the SDP the intervals and events for the periodic *evaluations* of corrective actions.
7. The *developer* **shall** report results of the periodic *evaluations* of corrective actions to management.
8. The *developer* **shall** review and follow up on corrective actions.

Note: The degree of formality of the *discrepancy and change reports* and the corrective action system can differ at different levels of corrective action.

5.18 Joint Technical and Management Reviews

This section specifies the developer *requirements* for joint (*acquirer* and *developer*) technical and management reviews.

Note: If a *system* or *software item* is developed in multiple *builds*, the types of *joint reviews* held and the criteria applied depend on the objectives of each *build*. Software *products* that meet those objectives can be considered satisfactory even though they are missing information designated for development in later *builds*.

5.18.1 Joint Technical Reviews

1. The *developer* **shall** plan and *participate* in joint technical reviews at locations and dates proposed by the *developer* and approved by the *acquirer*.
2. The joint technical review team **shall** include persons with technical knowledge of the domain.
3. The joint technical review team **shall** include persons with technical knowledge of the software *products* to be reviewed.
4. The joint technical reviews **shall** focus on in-process and final software *products*, rather than materials generated especially for the review.

Note: Additional requirements for joint technical reviews are specified in Appendix E, Joint Technical and Management Reviews. See E.2, E.3, and E.4 for objectives for Joint Technical Reviews.

5.18.2 Joint Management Reviews

1. The *developer* **shall** plan and *participate* in joint management reviews at locations and dates proposed by the *developer* and approved by the *acquirer*.
2. The joint management review team **shall** include persons with authority to make cost and schedule decisions.

3. The joint management reviews **shall** have the following objectives:
    a. Keep management informed about project status, directions being taken, technical agreements reached, and overall status of evolving software *products*.
    b. Review project status.
    c. Resolve *issues* that could not be resolved at joint technical reviews.
    d. Arrive at agreed-upon mitigation strategies for near- and long-term *risks* that could not be resolved at joint technical reviews.
    e. *Identify* and resolve management-level *issues* and *risks* not raised at joint technical reviews.
    f. Make recommendations for *acquirer approvals* needed for timely accomplishment of the project.

Note 1: *Acquirer* approval authority is required for some recommended actions.
Note 2: Additional *requirements* for joint management reviews are specified in Appendix E.5, Joint Management Reviews.

5.19 Software Risk Management *

1. The *developer* **shall** perform *software risk* management throughout the system development lifecycle.
2. The *developer* **shall**:
    a. *identify*, analyze, and prioritize the areas of the software development project that involve any potential software *risks*, whether technical, cost, or schedule *risks*;
    b. develop strategies for managing those software *risks*;
    c. *record* the software *risks* and strategies as specified in the SDP;
    d. implement the strategies in accordance with the plan; and
    e. track *risks* to closure.

5.20 Software Measurement

1. The *developer* **shall** plan, *record*, and perform software measurement throughout the system development lifecycle in accordance with ISO 15939, Systems and Software Engineering Measurement Process (ISO 15939).
2. The *developer* **shall** plan, *record*, and perform software measurement throughout the system development lifecycle following the guidance in (Abelson 2011).

5.20.1 Software Measurement Planning

1. The *developer* **shall** plan and *record* the project's *software* measurement approach for collecting, analyzing, interpreting, applying, and reporting each *software* measurement.
2. The measurement system specified in the planning **shall** be aligned with the other *contractual* measurement systems following the guidance specified in the Measurement Systems Alignment section of (Abelson 2011).
   Note: These other *contractual* measurement systems include, e.g., Work Breakdown Structure (WBS), Integrated Master Schedule (IMS), *risk* management.
3. The Software Measuremen Plan (SMP) for the software measurement activities required by this standard **shall** use the items in the Software Measurement Plan (SMP) template in Appendix H.4 Software Measurement Plan (SMP) Template as guidance for the SMP.
   Note: See Section 6.2 for the SMP template identifier.

Note: The exact *contractual requirements* for *deliverable products* are in the *contract*. Those *contractual requirements* state where the software measurement planning information is to be *recorded*. If the software measurement plan is not a deliverable, then the software measurement planning information *may* be included in Section 5.20 of the SDP or in a separate software measurement plan.

* SMC/EN note: For additional details on risk handling and other aspects of risk management, please refer to the SMC tailoring document that specifies SMC's risk management requirements, SMC-T-005.

5.20.2 Software Measurement Reporting

1. The *developer* **shall** perform the measurement process by collecting, analyzing, interpreting, applying, and reporting the required base measures, indicators, and derived measures specified in the Software Measurement Plan (SMP).
2. The *developer* **shall** perform the measurement *process* at the times specified in the SMP.
3. Measurement reporting **shall** be performed for each *software item*.
4. Measurement reporting **shall** be performed for each *build*.
5. The Software Measurement Report (SMR) **shall** use the items in the Software Measurement Report (SMR) template in Appendix H.5 Software Measurement Report (SMR) Template as guidance for the SMR.

   Note: See Section 6.2 for the SMR template identifier.

5.20.3 Software Measurement Working Group (SMWG)

1. A joint *acquirer* and *developer* software measurement working group (SMWG) **shall** be established to accommodate changing measurement needs throughout the system development lifecycle.

5.21 Security and Privacy

1. The *developer* **shall** meet the security *requirements* and the privacy *requirements* specified in the *contract*.

Note: These *requirements* can affect any combination of the software development methods, the software product standards, and the resulting software *products*.

5.22 Software Team Member Management

1. The *developer* **shall** include all software-related *contract* provisions from the *acquirer's contract* with the *prime contractor* into the agreements between all *software team members* performing *software*-related work on the *contract*.
2. Each *software team member* **shall** enforce the compliance of all subordinate *software team members* with the *software*-related *contract* provisions that have been placed in their respective agreements.

5.23 Interface with Software IV&V Agents

1. The *developer* **shall** interface with the software Independent Verification and Validation (IV&V) agent(s) as specified in the *contract*.

5.24 Coordination with Associate Developers

1. The *developer* **shall** coordinate with *associate developers*, working groups, and interface groups as specified in the *contract*.

5.25 Improvement of Project Processes

1. The *developer* **shall** define the method to be used to assess the *processes* in use on the project to determine their suitability, efficiency, and effectiveness.
2. The *developer* **shall** *document* in the SDP:
   a. the assessment method, and
   b. the periodic assessment schedule.
3. The *developer* **shall** periodically assess the *processes* used on the project to determine their suitability, efficiency, and effectiveness, as specified in the SDP.

4. Based on the assessment results, the *developer* **shall** perform the following process improvement planning:
   a. *identify* any necessary and beneficial improvements to the *processes*,
   b. plan for corrections to and improvements to the project's *processes*, and
   c. schedule the improvements and subsequent assessments.
5. The *developer* **shall** document the results of the process improvement planning in the Process Improvement Plan (PIP).
6. The resulting process improvement planning **shall** include all *applicable* items in the PIP template in Appendix H.6 Process Improvement Plan (PIP) template, as defined in the SDP (see Section 5.1.1).
   Note: See Section 6.2 for the PIP template identifier.
7. The *developer* **shall** execute process improvement in accordance with the PIP.
8. The *developer* **shall** update the project's *processes* per the improvements identified in the PIP.
9. The *developer* **shall** update the SDP as needed to include or reference the updated project *processes*.
10. The *developer* **shall** include assessment of the updated project *processes* in subsequent periodic assessments to determine whether the *developer* has achieved the expected beneficial improvements.
11. The *developer* **shall** update the PIP for each periodic assessment.

6. Notes

6.1 Intended Use

This section contains information of a general or explanatory nature that might be helpful, but is not mandatory.

6.2 Data Item Descriptions (DIDs)

The following *DIDs* are listed, as *applicable*, on the *Contract Data Requirements List* (*CDRL*) in order to have the *products* delivered under the *contract*.

DID Title	DID or Template Identifier
Software Development Plan (SDP)	DI-IPSC-81427A with Appendix H.1 content
Software Test Plan (STP)	DI-IPSC-81438A
Software Installation Plan (SIP)	DI-IPSC-81428A
Software Transition Plan (STrP)	DI-IPSC-81429A
Operational Concept Description (OCD)	DI-IPSC-81430A
System/Subsystem Specification (SSS)	DI-IPSC-81431A
Interface Requirements Specification (IRS)	DI-IPSC-81434A
System/Subsystem Design Description (SSDD)	DI-IPSC-81432A
Interface Design Description (IDD)	DI-IPSC-81436A
Software Requirements Specification (SRS)	DI-IPSC-81433A
Software Design Description (SDD)	DI-IPSC-81435A
Database Design Description (DBDD)	DI-IPSC-81437A
Software Test Description (STD)	DI-IPSC-81439A
Software Test Report (STR)	DI-IPSC-81440A
Software Product Specification (SPS)	DI-IPSC-81441A
Software Version Description (SVD)	DI-IPSC-81442A
Software User Manual (SUM)	DI-IPSC-81443A
Computer Operation Manual (COM)	DI-IPSC-81446A
Computer Programming Manual (CPM)	DI-IPSC-81447A
Firmware Support Manual (FSM)	DI-IPSC-81448A
Software Architecture Description (SAD)	DI-MISC-80508B with Appendix H.2 content
Software Master Build Plan (SMBP)	DI-MGMT-80004A with Appendix H.3 content
Software Measurement Plan (SMP)	DI-MGMT-80004A with Appendix H.4 content
Software Measurement Report (SMR)	DI-MISC-80508B with Appendix H.5 content
Process Improvement Plan (PIP)	DI-MGMT-80004A with Appendix H.6 content

Note 1: Depending on *CDRL* item provisions, *requirements* concerning system *interfaces* can be included in the SSS or in the Interface Requirements Specifications (IRSs).
Note 2: To *contractually* require only the executable *software* (delaying delivery of *source files* and associated support information to a later *build*), the *acquirer* can use the SPS *DID*, tailoring out all but the executable *software* section of that *DID*.

6.3 Deliverable Versus Nondeliverable Software Products

6.3.1 Philosophy of the Standard

This standard has been worded to differentiate between the planning and engineering activities that make up a software development project and the generation of deliverables. A key objective of this wording is to eliminate the notion that the *acquirer* needs to *contractually* require a given deliverable in order to have planning or engineering work take place. Under this standard, the planning and engineering work takes place regardless of which deliverables are *contractually* required, unless a given activity is tailored out of the standard. In addition, joint technical reviews have been included to review the results of that work in its natural form, without the generation of deliverables.

6.3.2 Contracting for Deliverables

Deliverables are *contractually* required only when there is a genuine need to have planning or engineering information transformed into a deliverable, recognizing that this transformation requires time and effort. The Description, Purpose, Use, or Relationship paragraph in a *DID* provides information that is helpful in deciding whether the corresponding deliverable is to be *contractually* required. The *acquirer* needs to consider future needs as well as the needs of the current *contract* when deciding which software *products* to make deliverable (e.g., future contracting for *software maintenance* or reprocurement). The *acquirer* also needs to consider future needs when establishing the data rights needed by the *acquirer* for the deliverable products. The data rights that the *acquirer* requires need to be specified in the *contract*.

6.3.3 Scheduling Deliverables

This standard has been structured to support a variety of development strategies and to provide the *developer* with flexibility in laying out a *software development process* that will best suit the work to be done. All of this flexibility can be canceled by rigid scheduling of deliverables in the *contract*. If the *contract* lays out a strict "waterfall" sequence of deliverables, little room is left to propose innovative development *processes*. If the *contract* forces all *software items* into lockstep with each other, little room is left to develop the *software items* in an optimum order. To the maximum extent possible, the *acquirer* needs to avoid such predetermination, allowing the *developer* to incrementally delivery software *products*, stagger the development of *software items*, and use other variations to optimize the software development effort. The *developer's* detailed software schedule that meets the constraints in the *contract* is documented in the SDP.

6.3.4 Format of Deliverables

Traditional deliverables (such as *CDRL* items based on *DIDs*) take the form of paper *documents* exactly following required formats and structure. While this form works well for some deliverables, it is not the only form, and alternatives need to be considered. One variation from paper *documents* is word processing files containing those *documents*. This format saves paper but still requires the *developer* to format and structure the information as required. Another variation is specifying that a paper or word processor *document* is to include all required contents but is allowed to be in the *developer's* format.

Yet another variation is allowing deliverables to take forms that are not traditional *documents* at all, such as data in computer-aided engineering (CAE) tools. These variations in required format can be specified in the *contract*, minimizing the time spent transforming actual *work products* into paper or electronic deliverables.

6.5 Tailoring Guidance

This standard and its *DIDs* are applied at the discretion of the *acquirer*. The *acquirer* is expected to tailor the standard and *DIDs* to the specific *requirements* of a particular project, *acquirer's* program phase, and *contractual* structure. Tailoring for the standard takes the form of deleting activities, modifying activities to more explicitly reflect the application to a particular effort, or adding activities

to satisfy the *acquirer's requirements*. This tailoring is specified in the *Statement of Work (SOW)* or Compliance Documents section of the *contract*. Tailoring for the *DIDs* consists of deleting *requirements* for unneeded information and making other changes, such as explanations of the meaning of the *DID* language, that do not increase the required workload. *DID* tailoring for an individual deliverable *product* is specified in the *contractual* form to the *CDRL* item.

In order for the *acquirer* to have approval authority for a particular *CDRL* item, the *acquirer* places the appropriate approval code in the *contractual* form for that *CDRL* item. (For DOD *contracts*, the DD 1423 form is used to place a *CDRL* item on *contract*.)

6.6 Related Standardization Documents

Other standards can be imposed or quoted in the *SOW* or Compliance Documents section of the *contract* to supplement the *requirements* in this standard. The *acquirer* needs to use caution to ensure that supplemental standards are appropriate to the project and that any conflicts among them or with this standard are identified and resolved.

Appendix A. List of Acronyms and Abbreviations

A.1 Scope

This appendix provides a list of acronyms and abbreviations used in this standard. This appendix is not a mandatory part of the standard. The information provided is intended for guidance only.

A.1.1 Acronyms and Abbreviations

Acronym or Abbreviation	Definition
§	section or paragraph
A	Analysis
ADS	appraisal disclosure statement
API	application programming interface
ARC	appraisal requirements for CMMI®
ASIC	application specific integrated circuit
CAE	computer-aided engineering
CAR	causal analysis and resolution
CASE	computer-aided software engineering
CDR	critical design review
CDRL	Contract Data Requirements List
CIO	chief information officer
CMMI®	Capability Maturity Model® Integration
CMMI®-DEV	Capability Maturity Model® Integration for Development
CMU	Carnegie Mellon University
CNSS	Committee on National Security Systems
CNSSI	CNSS Instruction
COM	Computer Operation Manual
COTS	commercial off-the-shelf
CSCI	computer software configuration item
CSU	computer software unit
CPM	Computer Programming Manual
CPU	computer processing unit
D	Demonstration
DAU	Defense Acquisition University
DBDD	Database Design Description
DCR	discrepancy and change report
DEV	Development
DID	Data Item Description
DOD	Department of Defense
EIA	Electrical Industries Association
FAR	Federal Acquisition Regulations
FPGA	field-programmable gate array
FMEA	failure modes and effects analysis
FSM	Firmware Support Manual
GUI	graphical user interface
I&T	integration and testing
I/O	input/output
I	Inspection
IA	information assurance
ICD	Interface Control Document

ID	identification
IDD	Interface Design Description
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IMP	integrated master plan
IMS	integrated master schedule
IRS	Interface Requirements Specification
ISO	International Organization for Standardization
IV&V	Independent Verification and Validation
KPP	Key Performance Parameter
MIL	military
MOSA	modular open software approach
MOU	memorandum of understanding
OCD	Operational Concept Description
OPM	organizational performance management
OPP	organizational process performance
OSS	open source software
PDR	preliminary design review
PIP	Process Improvement Plan
PLD	programmable logic device
QPM	quantitative project management
RMA	reliability, maintainability, and availability
SAD	Software Architecture Description
SAR	software requirements and architecture review
SBDR	software build design review
SBER	software build exit review
SBPR	software build planning review
SBRAR	software build requirements and architecture review
SBTRR	software build test readiness review
SCAMPI(SM)	Standard CMMI® Appraisal Method for Process Improvement
SDD	Software Design Description
SDF	software development file
SDL	software development library
SDP	Software Development Plan
SDR	system design review
SDSMCS	Software Development Standard for Mission Critical Systems
SEI	Software Engineering Institute
SFR	system functional review
SI	software item
SIP	Software Installation Plan
SIQT	software item qualification testing
SMBP	Software Master Build Plan
SMP	Software Measurement Plan
SMR	Software Measurement Report
SMWG	software measurement working group
SOW	statement of work
SPD	Software Product Development (TAI course)
SPS	Software Product Specification
SQA	software quality assurance
SRR	system requirements review
SRS	Software Requirements Specification

SSDD	System/Subsystem Design Description
SSS	System/Segment Specification or System/Subsystem Specification
STD	software test description
Std	standard
STD	standard
STP	Software Test Plan
STR	Software Test Report
STrP	Software Transition Plan
SUM	Software User Manual
SVD	Software Version Description
T	Test
TAI	The Aerospace Institute
TBD	to be determined
TBR	to be resolved
TBS	to be supplied
TBX	TBD, TBR, or TBS
TCS	target computer system
TOR	technical operating report
TPM	technical performance measure
TRR	test readiness review
UML	Unified Modeling Language
UOM	unit of measure
WBS	work breakdown structure

Appendix B. Interpreting This Standard for Incorporation of COTS and Other Reusable Software Products

B.1 Scope

This appendix is a MANDATORY part of this standard. It provides *evaluation* criteria for *reusable software products*.

See Section 3.1 for the definitions of terms in italics, such as *supplier* and *reusable software*, which includes *COTS software*.

B.2 Evaluating Reusable Software Products

See Section 3.1 for the definition of the term "*supplier*." Criteria for evaluating *reusable software products* **shall** include the following, as a minimum:

1. Ability to provide required capabilities and meet required constraints:
   a. Ability to satisfy *requirements;*
   b. Ability to achieve necessary performance, especially with realistic operational workloads;
   c. Appropriateness of algorithms in the *reusable software product* for use in the new *system;* and
   d. As evidenced by *characterization testing, stress testing*, and *prototyping* within the system context to determine capabilities and performance.
2. Ability to provide required protection, i.e., *safety*, *security*, and *privacy protection*:
   a. Inherently in the *reusable software product*,
   b. Around the *reusable software product* by system design and implementation, or
   c. The current product version is on an approved list of validated products for the domain and environment.
3. *Reliability* and maturity:
   a. As evidenced by prototype *evaluation* within the *system* context, and
   b. As evidenced by established track record (e.g., *discrepancy and change report* history).
4. *Testability*:
   a. As evidenced by the ability to identify and isolate faults; and
   b. Feasibility of testing or otherwise assessing complete conformance to *requirements* for behavior under *nominal* and *off-nominal conditions*, failure behavior, and recovery behavior.
5. Operability:
   a. Suitability of the *reusable software product's* implied operations concept to the operations concept of the new *system;* and
   b. Lack of functionality that would inhibit operations, such as a periodic need to enter in a license code or the presence of a physical key or similar device to enforce licensing conditions.
6. Viability of *reusable software product supplier*:
   a. Compatibility of *supplier's* future direction for the *reusable software* with project needs, including both *software* and platform emphasis;
   b. *Supplier* long-term commitment to the *reusable software product;*
   c. *Supplier* long-term business prospects;
   d. Type of *supplier* support available; and
   e. Quality of *supplier* support available.
7. Suitability for incorporation into the new *system architecture*:
   a. Compatible software *architecture* and design features,
   b. Absence of obsolete technologies,

c. Lack of or minimal need for re-engineering or additional code development (e.g., wraps, "glue" code),
d. Compatibility among the set of *reusable software products,* and
e. As evidenced by *prototyping* within the *system* context (e.g., to determine compatibility, wraps, "glue" code).

8. Ability to remove or disable features or capabilities not required in the new *system*:
   a. Impact if those features cannot be removed or disabled, or are not removed or disabled, and
   b. As evidenced by *prototyping* within the *system* context.
9. Interoperability with other *system* elements and external *system*s:
   a. Compatibility with *system* interfaces,
   b. Adherence to standards (e.g., open systems interface standards), and
   c. Ability to interface with legacy *systems.*
10. Availability of personnel knowledgeable about the *reusable software product*:
    a. Training required,
    b. Hiring required, and
    c. *Supplier* or third-party support required.
11. Availability and quality of documentation and *source* files:
    a. Completeness, and
    b. Accuracy.
12. Acceptability of *reusable software product* licensing and data rights:
    a. Restrictions on copying or distributing the *reusable software product* or documentation;
    b. License or other fees *applicable* to each copy;
    c. *Acquirer's* usage and ownership rights, especially to the *source code*:
       (1) Ability to use the *reusable software product* as needed by the *acquirer*, operator, *user*, and maintainer; and
       (2) Ability to place *source code* in escrow against the possibility of its *supplier* going out of business;
    d. Warranties available; and
    e. Absence of unacceptable restrictions in standard license (e.g., export restrictions, expiring keys).
13. Supportability:
    a. Suitability of the *reusable software product's* support paradigm (e.g., distribution, installation) to the support concept of the new *system*, especially for mobile or remote *user sites.*
14. Ability to make changes, including:
    a. Likelihood the *reusable software product* will need to be changed;
    b. Feasibility and difficulty of accomplishing that change when changes are to be made by the project reusing the software *product*:
       (1) Quality of design, code, and *documentation*; and
       (2) Need for re-engineering or restructuring, or both; and
    c. Feasibility and difficulty of accomplishing change when changes must be made by the *supplier* or product *developer* (e.g., for *COTS software* or proprietary *software*):
       (1) Priority of changes required by this project versus other changes being made,
       (2) Likelihood that the changed version will continue to be maintained by its *supplier* or *developer,*
       (3) Likelihood of being able to modify future versions to include changes,
       (4) Impact on lifecycle costs, and
       (5) Impact if the current version is not maintained by the *supplier* or if changes are not able to be incorporated into future versions.

Note: Modification of *COTS software* or of *open source software* managed like *COTS software* is strongly discouraged.

15. Impacts of upgrades to *reusable software products*:
    a. Frequency of *reusable software product* upgrades and modifications, i.e., completely new version or upgrade patches to the existing version being released, being made by its *supplier* after a particular version has been incorporated into the *system;*
    b. Feasibility and difficulty of incorporating the new version of the *reusable software product* into the *system;*
    c. Impact if the new version is not incorporated (e.g., loss of support); and
    d. Ability of the new *architecture* to support the evolution of *reusable software products.*
16. Compatibility of planned upgrades of *reusable software products* with *software development* plans and schedules:
    a. Compatibility of planned upgrades with *build* content and schedules,
    b. Impact on development costs and schedule to incorporate upgrades,
    c. Dependencies among *reusable software products*:
        (1) Potential for an incompatible set of *reusable software products*, and
        (2) Potential for schedule delays until all dependent *reusable software products* are upgraded.
17. Criticality of the functionality provided by the *reusable software product*:
    a. Appropriateness of the *reusable software product* to the criticality of the needed functionality, and
    b. Availability of alternate source(s) for the functionality.
18. Short- and long-term cost impacts of using the *reusable software product*:
    a. Amount of management reserve needed to handle uncertainties (for example, if less of a planned *reusable software product* is *reusable* than planned, then more newly developed *software* is required for that functionality):
        (1) *Reusable software product* limitations identified, and
        (2) Sufficient management reserve available for contingencies.
19. Technical, cost, and schedule risks and tradeoffs in using the *reusable software product*:
    a. Ability to tolerate *reusable software product* problems beyond the project's control at any point in the *system* lifecycle, and
    b. Ability to incorporate continuous evolution of *reusable software products* during development and maintenance.

Appendix C. Discrepancy and Change Reporting

C.1 Scope

This appendix is a MANDATORY part of this standard. This appendix specifies the necessary information for *discrepancy and change reports (DCRs)*, including category classification schemes.

C.2 Discrepancy and Change Reports

C.2.1 Discrepancy and Change Report Definitions

Discrepancy and change reports (*DCRs*) are *recorded* for *change requests, discrepancies*, and *test incidents* that occur from the beginning of the project through system retirement or project termination.

1. If the *developer* has alternative definitions for the *DCR* terms defined in this section, then the *developer* **shall** provide the definitions of those terms in the Software Development Plan (SDP).

Terms that apply to *discrepancy and change reports* (*DCRs*) are defined below. The definitions are listed in alphabetical order, matching as closely as possible the wording used in Table C.2-5.

Activity where detected. The name of the activity in which the *discrepancy* or *test incident* was detected. See Appendix C, Table C.2-2, Categories of Activities, for the activity names in this standard.

Activity where injected. The name of the activity in which the *discrepancy* was injected. See Appendix C, Table C.2-2, Categories of Activities, for the activity names in this standard.

Affected software and documentation components. The specific software *products*, *documents*, paragraphs, files, databases, or any combination to which the report applies.

Analyst assigned. The name of the analyst assigned. (This information is only intended for determining resource loads.)

Artifact types affected. The types of artifacts (e.g., plan, *requirements*, user guide) affected by the corrective action. See Appendix C, Table C.2-1, Categories of Software Products.

Cause classification. The type of cause of the *discrepancy* or *test incident.* For a *change request*, the cause classification is "enhancement." See Appendix C, Table C.2-4, Categories of Causes.

Configuration identifier(s). The project-specific configuration identifiers of the affected entities, (e.g., *software unit*, *build*, *software item*, *hardware item*).

Configuration identifier(s) after corrective action. See Configuration identifier(s) above.

Configuration identifier(s) before corrective action. See Configuration identifier(s) above.

Date analysis completed. The date the analysis was completed.

Date analyst assigned. The date the analyst was assigned.

Date closed. The date that the *DCR* was closed by the configuration control authority.

Date deployed. The date that the verified implementation solution was deployed at the *user site*.

Date implementation completed. The date that the implementation of the solution was completed.

Date implementer assigned. The date that the implementer was assigned.

Date of occurrence. The date of the *discrepancy* or *test incident*.

Date of origination. The date the *DCR* is written.

Date solution authorized for deployment. The date the configuration control authority authorized deployment of the implemented solution.

Date solution authorized for implementation. The date the configuration control authority authorized implementation of the solution.

Date verification completed. The date that *verification* of the solution was completed.

Date verifier assigned. The date that the verifier was assigned to verify the implemented solution.

DCR identifier. The assigned *DCR* identifier, often generated by the corrective action system.

DCR status. The corrective action system status as defined by the corrective action system procedures.

Description. A description of the *change request*, *discrepancy*, or *test incident*. For *discrepancies* and *test incidents*, the description includes what occurred, the conditions and activities leading to the occurrence, the date of occurrence, and the conditions, inputs, and equipment configuration under which the *discrepancy* or *test incident* occurred. For *discrepancies* and *test incidents*, the description includes sufficient information to permit duplication and analysis. It includes relationships to other reported *DCRs* and modifications, if any. For *change requests*, the description includes sufficient information to understand the requested change and its scope.

Description by analyst. See Description above.

Description by originator. See Description above.

Development severity classification. See Appendix C, Table C.2-3, Categories of Severity. The severity of the impact on development if not corrected, (e.g., blocking continued testing, schedule impact). Severity 1 is the highest severity. Contrast with "Operational severity classification" below.

Failure mode classification. The failure category that indicates the way the *software* performs incorrectly, (e.g., crash, hang, raise exception, issue error message and continue, provide wrong answer and continue, provide information too late to meet requirements). These failure categories are often defined in the project Failure Modes and Effects Analysis (FMEA) or in project corrective action procedures.

Impacts. The cost, schedule, performance, and interface impacts if the solution is approved. Also, the cost, schedule, performance, and interface impacts if the solution is not approved. Include the impact on the other *systems*, *software items*, *hardware items*, other team members, operations, integrated logistics support, system resources, training, and any other *applicable* impacts.

Implementation solution. A brief description of the implemented solution.

Operating time. Operating time is the interval from the time the *software* execution is started until the *software* stops execution due to either a normal exit or an abnormal termination. Operating time units (e.g., hours, minutes, seconds) are also included. Operating times can be aggregated (e.g., if 10 replicas of the item under *test* are operating simultaneously on different data, or if the operating time is reported as the sum of individual operating times from multiple tests). This item only applies to testing and operations activities.

Operational severity classification. See Appendix C, Table C.2-3, Categories of Severity. The severity of the impact on operations or that would affect operations if not corrected before being installed in the operational environment. Severity 1 is the highest severity. Contrast with Development severity classification above.

Originator. The name, telephone number, email address, and organization of the person submitting the report.

Reason for change. The reason that the change is needed. This item only applies to *change requests*.

Recommended solution. After analysis of the *change request*, *discrepancy*, or *test incident*, the recommended solution and alternative solutions, if available. When *applicable*, include supporting rationale and test results.

Short name. A unique, descriptive, short name for the *DCR*.

Start time. The time at which the *software* begins execution. Time units are provided, i.e., either wall-clock time, including time zone, or time before or after a significant related event (e.g., installation, launch, start of a mission phase, thruster firing, partial service interruption). If operating time is reported, then this item is optional. If operating time is not reported, then start times are reported for each *discrepancy* and *test incident*. This item only applies to *testing* and operations activities.

Stop time. The time at which the *software* ends execution due to a normal or abnormal termination. Time units are provided, i.e., either wall-clock time, including the time zone, or time after a significant related event. If operating time is reported, then this item is optional. If operating time is not reported, then stop times are reported for each *discrepancy* and *test incident*. This item only applies to testing and operations activities.

System or project name. The name of the *system* or development project to which the *DCR* report applies.

Verifier assigned. The name of the verifier assigned. (This information is only intended for determining resource loading.)

Version identifier(s). The *software build,* or equivalent, version identifiers, individual *software unit* version identifiers, hardware version identifiers, or other level of version identifiers for the particular software and hardware configurations to which the *DCR* report applies.

Version identifier(s) before corrective action. See Version identifier(s).

Version identifier(s) after corrective action. See Version identifier(s).

Version identifier(s) after implementation. See Version identifier(s). Note: This item might need updating during *verification* and for deployment.

Table C.2-1 Categories of Software Products

Identifier	Software Product Categories
a.	Plans for the project
b.	Operational concept
c.	Architecture of the *system*, *subsystem*, or *software*
d.	Requirements for the *system*, *subsystem*, or *software*
e.	Design of the *system*, *subsystem*, or *software*
f.	*Software* (e.g., code, scripts)
g.	*Database* or data file
h.	Test plan, *test case*, *test procedure*, test script, test data
i.	Test reports
j.	Manuals and guides, i.e., user, operator, or support manuals or guides
k.	Standards or policies
l.	*Software development processes* or procedures
m.	Reports other than test reports
n.	Other *software products*

Note: This set of categories is called "discrepancy source" in (Abelson 2011).

Table C.2-2 Categories of Activities

Section	Activity Categories
5.1	Project planning and oversight
5.2	Establishing a software development environment
5.3	System requirements analysis
5.4	System architecture and design
5.5	Software requirements analysis
5.6	Software architecture and design
5.7	Software implementation and unit testing
5.8	Unit integration and testing
5.9	Software item qualification testing
5.10	Software-hardware item integration and testing
5.11	System qualification testing
5.12	Preparing for software transition to operations
5.13	Preparing for software transition to maintenance
5.14	Software configuration management
5.15	Software peer reviews and product evaluations
5.16	Software quality assurance
5.17	Corrective action
5.18	Joint technical and management reviews
5.19	Software risk management
5.20	Software measurement
5.21	Security and privacy
5.22	Software team member management
5.23	Interface with software IV&V agents
5.24	Coordination with associate developers
5.25	Improvement of project processes

Table C.2-3 Categories of Severity

Severity	Description
1	a. Prevents the accomplishment of an operational or essential mission capability b. Jeopardizes safety, security, or other requirement designated "critical"
2	a. Adversely affects the accomplishment of an operational or essential mission capability, and no workaround solution is known b. Adversely affects technical, cost, or schedule risks to the project or to lifecycle support of the system, and no workaround solution is known
3	a. Adversely affects the accomplishment of an operational or mission essential capability, but a workaround solution is known b, Adversely affects technical, cost, or schedule risks to the project or to lifecycle support of the system, but a workaround solution is known
4	a. Results in user or operator inconvenience or annoyance but does not affect a required operational or mission essential capability b. Results in inconvenience or annoyance for development or maintenance personnel, but does not prevent the accomplishment of those responsibilities
5	Any other effect

Table C.2-4 Categories of Causes

Category	Description
a. Logic	Logic problem
b. Computational	Computation problem
c. Interface	Interface problem
d. Timing	Timing problem
e. Data handling	Data handling problem, including, e.g., initialization, access, storage, scaling, units
f. Data problem	Incorrect or missing data
g. Documentation*	*Documentation* problem, including, e.g., unclear, missing, conflicting, redundant, confusing, illogical information in documentation
h. Document quality	*Documentation* problem (e.g., incomplete information, not meeting standards, not traceable, not current, inconsistencies)
i. Enhancement	A proposed change for improvement (e.g., new *requirement)*
j. Syntax	Nonconformity with defined language rules
k. Standards	Nonconformity with a defined standard
l. Other	Other problem

*The *Documentation* category includes many types of *documentation* (e.g., *requirements*, *architecture*, *design*, user *documentation*). The *developer may* use subcategories of *documentation* to capture these distinctions.

C.2.2 Discrepancy and Change Report Requirements

This section specifies the *requirements* for *discrepancy and change reports*.

1. The *developer* **shall** include in each *DCR for discrepancies* and *test incidents*, as a minimum, the information specified as "Yes" in the *Discrepancy* and *Test Incident* column of Table C.2-5 for the development activities defined in Section 5 of this standard.
   Note: For unit *testing*, this information is optional.
2. The *developer* **shall** include in each *DCR* for *change requests*, as a minimum, the information specified as "Yes" in the Change Request column of Table C.2-5 for the development activities defined in Section 5 of this standard.
3. The *developer* **shall** record all instances of the same *change request*, *discrepancy*, and *test incident*, if any, in *discrepancy and change reports*.
4. The developer *should* provide the solution to the originator for *verification*.

Note 1: The *developer may* record additional *DCR* information.

Note 2: The *developer may* record additional information for any development activity.

Table C.2-5 Discrepancy and Change Report Information

ID	Discrepancy and Change Report Information Item	Discrepancy and Test Incident	Change Request
	Initiation Information		
1.	*DCR* identifier	Yes	Yes
2.	Short name of *DCR*	Yes	Yes
3.	*System* or project name	Yes	Yes
4.	Originator	Yes	Yes
5.	Date of origination	Yes	Yes
6.	Description by originator	Yes	Yes
7.	Reason for change	No	Yes
8.	Operational severity classification	Yes	Yes
9.	Date of occurrence	Yes	No
10.	Operating time OR Start time AND Stop time Note: This information is only required for test and operations activities.	Yes	No
	Analysis Information		
11.	Description by analyst	Yes	Yes
12.	Development severity classification	Yes	Yes
13.	Activity where detected	Yes	No
14.	Activity where injected	Yes	No
15.	Failure mode classification	Yes	No
16.	Artifact types affected	Yes	Yes
17.	Affected *software* and *documentation components*	Yes	Yes
18.	Configuration identifier(s) before corrective action	Yes	Yes
19.	Version identifier(s) before corrective action	Yes	Yes
20.	Cause classification	Yes	Yes
21.	Recommended solution	Yes	Yes
22.	Impacts	Yes	Yes
	Implementation Information		
23.	Artifact types affected	Yes	Yes
24.	Affected *software* and *documentation components*, including file names	Yes	Yes
25.	Configuration identifier(s) after corrective action	Yes	Yes
26.	Version identifier(s) after corrective action	Yes	Yes
27.	Implementation solution	Yes	Yes
	Status Information		
28.	*DCR* status*	Yes	Yes
29.	Date analyst assigned	Yes	Yes
30.	Analyst assigned	Yes	Yes
31.	Date analysis completed	Yes	Yes
32.	Date solution authorized for implementation	Yes	Yes
33.	Date implementer assigned	Yes	Yes

ID	Discrepancy and Change Report Information Item	Discrepancy and Test Incident	Change Request
34.	Date implementation completed	Yes	Yes
35.	Date verifier assigned	Yes	Yes
36.	Verifier assigned	Yes	Yes
37.	Date verification completed**	Yes	Yes
38.	Date solution authorized for deployment	Yes	Yes
39.	Date closed	Yes	Yes
40.	Date deployed	Yes	Yes

* The *developer may* have several categories of status, (e.g., open, accepted, rejected, deferred, fixed, verified, closed). The *developer's DCR* status categories are specified in the SDP.

** See Section C.2.2 #4.

Appendix D. Product Evaluations

D.1 Scope

This appendix is a MANDATORY part of this standard. It specifies the *requirements* and *evaluation* criteria for product *evaluations*.

D.2 Criteria Definitions

The following subsections provide definitions for wording used in the *evaluation* criteria specified in Table D.3-1 that might not be self-explanatory. The criteria are listed in alphabetical order, matching as closely as possible the wording used in Table D.3-1.

1. The definitions provided in Section D.2 **shall** be used to interpret the *evaluation* criteria provided in Table D.3-1.
2. If the *developer* has alternative definitions for the *evaluation* criteria terms defined in Appendix D, Section D.2, then the *developer* **shall** provide the definitions of those terms in the Software Development Plan (SDP).
3. If the *developer* has additional *evaluation* criteria planned for use in product *evaluations*, those criteria **shall** be defined in the SDP.

D.2.1 Accurately Describes (an Item)

This criterion, applied to *user*, operator, or programmer instructions and to the "as built" *design* and version descriptions, means that the instructions or descriptions are correct depictions of the *software* or other item described.

D.2.2 Adequate Tests, Test Cases, Procedures, Data, and Results

Tests, as described in the Software Test Plan, are adequate if they address all *applicable requirements* and *verification methods* and are described in enough detail to guide the development of the *test cases* for the cited *requirements* and *verification methods*. *Test cases* are adequate if they cover all *applicable requirements* or design decisions and specify the *verification methods*, prerequisite conditions, inputs to be used, the *expected results*, and the criteria to be used for evaluating those results. *Test procedures* are adequate if they specify the execution steps to be followed in carrying out each *test case*, *expected results,* the criteria to be used for evaluating those results, and the steps for analysis. Test data are adequate if they enable the execution of the planned *test cases* and *test procedures*. Test or dry run results are adequate if they describe the results of all *test cases* and show that all criteria have been met, possibly after revision and retesting.

D.2.3 Component-Based

This criterion means that the software *architecture* consists of *components* with well-defined *interface* and service semantics that operate over an underlying infrastructure. The software *architecture documents* the software *components*, their semantics, the *interfaces,* including data and control, among them, and external software-software and software-hardware *interfaces*.

D.2.4 Consistent with Indicated Product(s)

This criterion means that:

1. No statement or representation in one *product* contradicts a statement or representation in the other *products*;
2. A given term, acronym, or abbreviation means the same thing in all of the *products*; and
3. A given item or concept is referred to by the same name or description in all of the *products*.

D.2.5 Contains All Applicable Information

This criterion uses the product contents specified in this standard or in the SDP if the product content is not specified in this standard for the required contents of the *products* that are not deliverable. This criterion uses the *Data Item Descriptions* (*DIDs)* or templates, as tailored for the *contract*, to specify the required content of the *products*. (See Section 6.2 for a list of the *DID* and template identifiers for product contents.) The formatting specified in the *DID,* i.e., required structure and numbering, is not relevant to this *evaluation*. The SDP describes the artifacts and other information to be developed and recorded for each *product* required by this standard (see Section 5.1.1).

D.2.6 Covers (a Given Set of Items)

A *product* "covers" a given set of items if every item in the set has been adequately dealt with in the *product*. For example, a plan covers the *Statement of Work* (*SOW)* if every provision in the *SOW* is addressed in the plan; a *design* covers a set of *requirements* if the *design* enables the satisfaction of every *requirement* in the set; a test plan covers a set of *requirements* if every *requirement* is the subject of one or more *tests* that will verify the *requirement*. "Covers" is related to the *bidirectional traceability* (for example, from *requirements* to *design* and back) in the *requirements*, *architecture*, *design*, and test planning and test description *products*.

D.2.7 Feasible

This criterion means that, based upon the knowledge and experience of the evaluator, a given concept, *architecture*, set of *requirements*, *designs*, *tests*, etc. violates no known principles or lessons learned that would render it impossible to carry out.

D.2.8 Follows SDP

This criterion means that the software *product* shows evidence of having been developed in accordance with the approach described in the SDP and its updates. Examples include following design and coding standards specified in the plan. For the SDP itself, this criterion applies to updates to the initial plan.

D.2.9 Includes Multiple Perspectives

This criterion means that the software *architecture* includes multiple perspectives, including both models and detailed textual descriptions of the logical organization; dynamic behavior; process decomposition, including any process priorities, scheduling dependencies, and workflow rates; software organization; physical realization of the *software*; and data model.

D.2.10 Internally Consistent

This criterion means that:

1. No two statements or representations in a product contradict one another;
2. A given term, acronym, or abbreviation means the same thing throughout the product; and
3. A given item or concept is referred to by the same name or description throughout the product.

D.2.11 Levels of Detail

This criterion means that the *architecture* or *design* representation shows high-level *components* and *interfaces* as well as other lower-level *components* and *interfaces* that *transition* to the software *design*.

Note: The level of detail evolves over time from high-level *software architecture components* and *interfaces* to multiple lower-level *components* and *interfaces* that *transition* to the software *design*.

D.2.12 Meets SOW and Contract, if Applicable

This criterion means that the *product* fulfills all *SOW* and *contract* provisions, if any, regarding it. For example, the *SOW* might place constraints on the operational concept or the *design*. The *contract*

might have special provisions concerning software architecture *evaluations*, process appraisals, data rights, or other standards that contain software *requirements*.

D.2.13 Presents a Sound Approach

This criterion means that, based on the knowledge and experience of the evaluator, a given plan represents a reasonable way to carry out the required activities.

D.2.14 Shows Evidence that an Item Under Test Meets its Requirements

This criterion means that recorded test results show that the item under *test* either passed all *tests* the first time or was revised and retested until the *tests* were passed.

D.2.15 Testable

A *requirement* or set of *requirements* is considered to be testable if an objective and feasible *test* using one or more of the four *verification methods*, i.e., Inspection, Analysis, Demonstration, and Test, can be designed to determine whether each *requirement* has been met.

D.2.16 Understandable

This criterion means "understandable by the intended audience." For example, software *products* intended for programmer-to-programmer communication need not be understandable by nonprogrammers. A *product* that correctly identifies its audience and is considered understandable to that audience meets this criterion.

D.2.17 Uses Software Engineering Tools and Techniques

This criterion means that the software *product* was produced using software engineering tool(s) and techniques for representing, *documenting*, and analyzing the *product*, including consistency analysis, and traceability mapping. For *architecture*, this includes using graphical architecture modeling techniques, e.g., Unified Modeling Language (UML).

D.3 Required Evaluations

Table D.3-1 specifies the *products* for which product *evaluations* are to be performed and the *evaluation* criteria to be used in those product *evaluations*. This table is a mandatory part of this standard (see Section 5.15.2.1 for the *requirements* that reference this table). If a *product* is not required to be delivered, the product *evaluation* is still required. However, if the development of a given *product* has been tailored out of the standard, the *requirement* to evaluate that *product* does not apply. Appendix D, Section D.2 provides the definitions of terms used in Table D.3-1.

Each *product* and criterion is labeled for purposes of identification and tailoring. For convenience, they can be treated as subsections of this section (referring to the first *product* and its first criterion, for example, as D.3.1.a.). The product names are expressed in lowercase letters to convey that they are generic *products*, not necessarily in the form of hard-copy *documents* or *deliverable products*. *Evaluations* of *system*-level *products* are interpreted as *participation* in these *evaluations*. Because some of the criteria are subjective, there is no *requirement* to prove that the criteria have been met; the *requirement* is to perform the *evaluations* using these criteria and to identify possible *discrepancies* for discussion and resolution.

Table D.3-1 Products and Associated Evaluation Criteria

ID	Product	Evaluation Criteria
1.	Software development plan §§ 5.1.1, 5.1.6	a. Contains all *applicable* information in SDP template (see Appendix H.1). b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP for updates to the plan. g. Covers all activities and deliverable *requirements* in the SOW and the SDP *CDRL* item. h. Covers all activities and *products* in this standard. i. Consistent with other project plans. j. Presents a sound approach to the development.
2.	Software master build plan §§ 5.1.2.1, 5.6.1, 5.6.2	a. Contains all *applicable* information in SMBP template (see Appendix H.3). b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Covers all software *build*-related activities and deliverable *requirements* in the *SOW* and the SMBP *CDRL* item, if *applicable*. h. Covers all software *requirements* and *software units*. i. Consistent with the software *requirements,* software *architecture,* and software *design*. j. Presents a sound approach to the integration and delivery.
3.	Software test plan §§ 5.1.2.2, 5.1.6	a. Contains all *applicable* information in STP *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Covers all software-related qualification activities and deliverable *requirements* in the *SOW* and the STP *CDRL* item, if *applicable*. h Covers all *requirements* for the *software items* under *test*. i. Consistent with other project plans. j. Presents a sound approach to the *testing*. k. Contains adequate *tests*. l. Contains adequate plans for a test environment that is sufficiently representative of operations, adequate for the full workload on the environment, and appropriately validated.
4.	System test plan for a *software-only system* §§ 5.1.3, 5.1.6	a. Contains all *applicable* information in STP *DID* (for a *software-only system*) or *system test* plan *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Covers all software-related qualification activities and deliverable *requirements* in the *SOW* and the STP or *system* test plan *CDRL* item, if *applicable*.

ID	Product	Evaluation Criteria
		h. Covers all system *requirements* for the items under *test*. i. Consistent with other project plans. j. Presents a sound approach to the testing. k. Contains adequate tests. l. Contains adequate plans for a *test* environment that is sufficiently representative of operations, adequate for the full workload on the environment, and appropriately validated.
5.	Software installation plan §§ 5.1.4, 5.1.6	a. Contains all *applicable* information in SIP *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Covers all *user site* installation activities and deliverable *requirements* in the *SOW* and the SIP *CDRL* item, if *applicable*. h. Consistent with other project plans. i. Presents a sound approach to the installation.
6.	Software transition plan §§ 5.1.5, 5.1.6	a. Contains all *applicable* information in STrP *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Covers all *transition*-related activities and deliverable *requirements* in the *SOW* and the STrP *CDRL* item, if *applicable*. h. Consistent with other project plans. i. Presents a sound approach to the *transition*.
7.	Operational concept description § 5.3.2	a. Contains all *applicable* information in OCD *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows systems engineering management plan and SDP, as *applicable*. g. Covers all *software*-related operations concept activities and deliverable *requirements* in the *SOW* and the OCD *CDRL* item, if *applicable*. h. Feasible. i. Consistent with *user's* concept of operations and *acquirer's* technical *requirements* document. j. Consistent with developer's SSS and SSDD.
8.	*System* and *subsystem requirements* §§ 5.3.3, 5.13.7	a. Contains all *applicable* information in SSS and IRS *DID*s. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows system engineering management plan and SDP, as *applicable*. g. Covers all *system* and *subsystem* requirements activities and deliverable *requirements* in the *SOW* and the SSS and IRS *CDRL* items, if *applicable*. h. Feasible.

ID	Product	Evaluation Criteria
		i. Covers the parent or predecessor *requirements* allocated to the *system* or *subsystem*. j. Consistent with the *user's* concept of operations and *acquirer's* technical *requirements* document. k. Consistent with the developer's operational concept. l. Consistent with the developer's *system* and *subsystem architecture*. m. *Testable*. n. Specifies the *verification method* for each *requirement*.
9.	System-wide architectural *design* decisions § 5.4.1	a. Contains all *applicable* information in SSDD *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows system engineering management plan and SDP, as *applicable*. g. Covers all system-wide architecture design activities and deliverable *requirements* in the *SOW* and SSDD *CDRL* item, if *applicable*. h. Consistent with the *system requirements*, including interface and database *requirements.* i. Consistent with the *user's* concept of operations and developer's operations concept description. j. Feasible.
10.	System architectural design § 5.4.2	a. Contains all *applicable* information in SSDD *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows system engineering management plan and SDP, as *applicable*. g. Covers all system architectural design activities and deliverable *requirements* in the *SOW* and SSDD *CDRL* item, if *applicable*. h. Covers the *system* and *subsystem requirements*, including interface and database *requirements*. i. Consistent with the system-wide design decisions, *system* and *subsystem requirements*, *user's* concept of operations, and developer's operations concept description. j. Feasible.
11.	Software *requirements* and software interface *requirements* §§ 5.5, 5.13.6	a. Contains all *applicable* information in SRS and IRS *DID*s. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Covers all software *requirements*-related activities and deliverable *requirements* in the *SOW* and the SRS and IRS *CDRL* items, if *applicable*. h. Covers all system and subsystem *requirements* allocated to the *software item*. i. Feasible. j. *Testable*.

ID	Product	Evaluation Criteria
		k. Each *requirement*, including *interface* and *derived requirements*, has been *bidirectionally traced* to its *parent* and back. l. Each *requirement* has its *verification method(s)* specified. m. All *requirements* have been reviewed, and any *discrepancies* have been reported and corrected.
12.	Overall *software architecture* §§ 5.6.1, 5.13.4	a. Contains all *applicable* information in SAD template (see Appendix H.2). b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Covers all software architecture activities and deliverable *requirements* in the *SOW* and SAD *CDRL* items, if *applicable.* h. Covers all software *requirements*, including interface *requirements*. i. Consistent with system and subsystem *requirements*. j. Consistent with overall software *requirements*. k. The modeling analysis shows evidence the *architecture* will meet the required margin reserves of the *target computer system(s)* selected (see Section 4.2.6). l. Able to meet each *software item's* allocated computer resource reserve margin *requirements*, given the selected *computer hardware* and the software and interface *requirements* to be met. m. Feasible. n. *COTS software* trial results and product and vendor viability reports reviewed and risk mitigation plans updated. o. *COTS software* and any other *reusable software* are isolated for possible later substitution. p. Rationale for architecture decisions included, including any current technology constraints. q. Component-based. r. Consistent with system and subsystem *architecture* and *design*. s. Includes multiple architecture perspectives. t. Uses *software engineering* tools and techniques. u. Uses graphical *architecture* modeling techniques, e.g., Unified Modeling Language (UML). v. Contains an appropriate level of detail.
13.	*Software item architecture* §§ 5.6.2, 5.13.4	a. Contains all *applicable* information in SAD template (see Appendix H.2). b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Covers all software item architecture activities and deliverable *requirements* in the *SOW* and SAD *CDRL* items, if *applicable*. h. Covers all software item *requirements*, including interface *requirements*. i. Consistent with overall software *requirements,* including interface *requirements*.

ID	Product	Evaluation Criteria
		j. Consistent with system and subsystem *requirements*. k. Consistent with overall software architecture and design decisions. l. Consistent with system and subsystem *architecture* and *design*. m. Able to meet the *software item's* allocated computer resource reserve margin *requirements*, given the selected computer hardware and the software and interface *requirements* to be met. n. Feasible. o. *Testable*. p. *COTS software* trial results and product and vendor viability reports reviewed and risk mitigation plans updated. q. *COTS software* and any other *reusable software* are isolated for possible later substitution. r. Rationale for *architecture* decisions is included, including any current technology constraints. s. Component-based. t. Includes multiple architecture perspectives. u. Uses software engineering tools and techniques. v. Uses graphical architecture modeling techniques, e.g., Unified Modeling Language (UML). w. Contains an appropriate level of detail.
14.	*Software item* detailed *design* §§ 5.6.3, 5.13.4	a. Contains all *applicable* information in SDD, IDD, and DBDD *DIDs*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP, including design standards. g. Covers all software design activities and deliverable *requirements* in the *SOW* and software, interface, and database *design CDRL* items, if *applicable.* h. Covers all software item *requirements* allocated to each unit. i. Consistent with software item *architecture*. j. Consistent with software item-wide design decisions. k. Feasible for *design*, implementation, operations, and *maintenance*. l. *Testable*. m. Consistent with possibly updated software estimates. n. *COTS software* and any other *reusable software product* trial results along with product and vendor viability reports reviewed and *risk* mitigation plans updated. o. *COTS software* and other *reusable software* isolated for possible later substitution. p. *Design* modifications of *reusable software* necessary, correct, and complete for satisfying the *requirements* allocated to this reuse, and software estimates updated accordingly.

ID	Product	Evaluation Criteria
15.	Software implementation, i.e., code and other necessary files, e.g., data files, *database* files, *build* files § 5.7.1	a. Meets *SOW*, if *applicable*. b. Meets *contract*, if *applicable*. c. Understandable. d. Internally consistent. e. Follows SDP, including coding standards. f. Covers the software item detailed *design*. g. Consistent with software *architecture* and software item-wide design decisions. h. Feasible for operations and *maintenance*. i. *Testable*. j. Algorithms properly implemented. k. *COTS software* and other *reusable software* isolated for possible later substitution. l. Follows coding standards that do not allow dangerous practices and that enhance *dependability*, as *applicable* to the software language and *category of software*. m. Analyzed using static and dynamic code analysis tools to ensure coding standards are met and no vulnerabilities exist.
16.	Software unit testing test cases, procedures, and results §§ 5.7.2, 5.7.3, 5.7.4, 5.7.5, 5.7.6	a. Meets *SOW*, if *applicable*. b. Meets *contract*, if *applicable.* c. Understandable. d. Internally consistent. e. Follows SDP. f. Covers all units in the software item detailed *design*. g. *Test cases, procedures*, data, and results provide evidence that the units fully and correctly implement the *design* and satisfy their allocated *requirements*. h. Satisfies the *requirements* of Section 5.7. i. *Test cases, procedures, data,* and results are captured in *SDFs.*
17.	Software integration testing test cases, procedures, and results §§ 5.8.1 through 5.8.6	a. Meets *SOW*, if *applicable*. b. Meets *contract*, if *applicable.* c. Understandable. d. Internally consistent. e. Follows SDP. f. Consistent with the integration sequence in the SMBP. g. Covers the integration of all *software* in the software item *architecture* and detailed *design,* including all *reusable software,* modified *reusable software,* and newly developed *software*. h. *Test cases, procedures*, data, and results provide evidence that the integrated *software* fully and correctly implements the *design* and satisfies its allocated *requirements*. i. Satisfies the *requirements* of Section 5.8. j. *Test cases, procedures, data,* and results are captured in *SDFs.*
18.	Software item qualification test descriptions §§ 5.9.3, 5.9.8	a. Contains all *applicable* information in STD *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Covers all planned software *qualification tests*. h. Covers all software item and software interface *requirements*. i. Consistent with the software test plan.

ID	Product	Evaluation Criteria
		j. Contains *test cases*, *procedures*, *databases*, and data that will enable the software *requirements* to be verified. k. Contains an appropriate level of detail for the *test procedures* to be repeatable. l. *Test cases* are consistent with the *verification methods* and levels in the software and interface *requirements specifications* and in the software test plan. m. Software and software interface *requirements* are allocated to *test procedure* steps that in combination completely cover the *requirements*. n. Feasible. o. Covers all of the software item *verification requirements* in Section 5.9.
19.	Software item qualification test results § 5.9.6 See § 3.1 for definition of *verification method* and definitions of A = Analysis, D = Demonstration, I = Inspection, and T = Test	a. Contains all *applicable* information in STR *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Covers all planned software item qualification *test cases*. h. Covers all planned software item and software interface *requirements*. i. Contains as run redlined *test procedures*, with software quality assurance witness signature or stamp indicating that the *test procedures* were executed as redlined. j. Contains complete *documentation* of all *test* results and all post-test analyses performed for *requirements* with *verification methods Demonstration* and *Test*. k. Contains complete analysis for all *requirements* with *verification method Analysis* and complete evidence that the *Inspection* was performed for all *requirements* with *verification method Inspection*. l. Shows evidence that the *software item* meets all of its *functional, performance,* and other *nonfunctional requirements*, using both *nominal* and *off-nominal* scenarios. m. Shows evidence that all *discrepancies* detected during software item qualification dry runs and formal execution have been recorded and entered into the *discrepancy* reporting system. n. Shows evidence that the *verification* status of the *requirements* under *test* is maintained in an enduring manner and that the status accurately reflects the results of the software item *qualification testing*. o. Shows evidence that the test environment configuration used for the formal execution is consistent with that described in the *test procedures* before the *testing* began, and if there are differences between the as run *test* environment configuration and that described in the *test procedure*, then all differences are explained and shown not to affect the *verification* of the *requirements*.

ID	Product	Evaluation Criteria
20.	Software-hardware integration testing test cases, procedures, and results §§ 5.10.1 through 5.10.6	a. Meets *SOW*, if *applicable*. b. Meets *contract*, if *applicable.* c. Understandable. d. Internally consistent. e. Follows systems engineering management plan and SDP, as *applicable*. f. Consistent with the software and hardware integration sequence in the SMBP. g. Covers the integration of all *software* and *target computer system* hardware in the software *architecture.* h. Contains *test cases*, *procedures*, *databases*, and data that enable the software-hardware interface *requirements* to be verified. i. *Test cases, procedures*, data, and results provide evidence that the integrated software and *target computer system* hardware fully and correctly implement the *design* and satisfy their allocated *requirements*. j. Satisfies the *requirements* of Section 5.10. k. *Test cases, procedures,* data*,* and results are captured in *SDFs.*
21.	*System* and *subsystem* qualification test descriptions §§ 5.11.3, 5.11.8	a. Contains all *applicable* information in the system and subsystem test description *DID* (or STD *DID* for a *software-only system*). b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows systems engineering management plan and SDP, as *applicable*. g. Covers all planned *system* and *subsystem qualification tests*. h. Covers all planned *system* and *subsystem requirements*, including interface *requirements*. i. Consistent with the *system* and *subsystem test* plan(s). j. Contains *test cases*, *procedures*, *databases*, and data that enable the *system* and *subsystem requirements*, including interface *requirements*, to be verified. k. Contains an appropriate level of detail for the *test procedures* to be repeatable. l. *Test cases* are consistent with the *verification methods* and levels in the *system* and *subsystem requirements. specification(s)* and in the *system* and *subsystem* test plan(s). m. *System* and *subsystem requirements*, including interface *requirements*, are allocated to *test procedure* steps that in combination completely cover the *requirements*. n. Feasible.

ID	Product	Evaluation Criteria
22.	*System* and *subsystem* qualification test results § 5.11.6 See § 3.1 for definition of *verification method* and definitions of A = Analysis, D = Demonstration, I = Inspection, and T = Test	a. Contains all *applicable* information in *system* and *subsystem test* report *DID* (or STR *DID* for a software-only *system*). b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows systems engineering management plan and SDP, as *applicable*. g. Covers all planned *system* and *subsystem qualification test cases*. h. Covers all planned *system* and *subsystem requirements,* including interface *requirements*. i. Contains as run redlined *test procedures*, with quality assurance witness signature or stamp indicating that the *test procedures* were executed as redlined. j. Contains complete *documentation* of all *test* results and all post-*test* analysis performed for *requirements* with *verification methods Demonstration* and *Test*. k. Contains complete analysis for all *requirements* with *verification method Analysis* and complete evidence that the *Inspection* was performed for all *requirements* with *verification method Inspection*. l. Shows evidence that the *system* and *subsystem* meet all of their *functional, performance,* and other *nonfunctional requirements*, using both *nominal* and *off-nominal* scenarios. m. Shows evidence that all *discrepancies* detected during *system* and *subsystem qualification* dry runs and formal execution have been recorded and entered into the *discrepancy* reporting system. n. Shows evidence that the *verification* status of the *requirements* under *test* is maintained in an enduring manner and that the status accurately reflects the results of the *system* and *subsystem qualification testing*. o. Shows evidence that the *test* environment configuration used for the formal execution is consistent with that described in the *test procedures* before the *testing* began, and if there are differences between the as run *test* environment configuration and that described in the *test procedure*, then all differences are explained and shown not to affect the *verification* of the *requirements*.
23.	Executable software §§ 5.12.1, 5.13.1	a. Meets all *requirements* in Section 3.1 of SPS DID. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Meets delivery *requirements*. h. Contains all *software* necessary for execution. i. Shows evidence that the version of the executable *software* exactly matches the version that passed *testing*. j. Deliverable media accurately labeled. k. Shows evidence that the version of the executable *software* was created from the specific identified configuration-managed version of the *source code*.

ID	Product	Evaluation Criteria
24.	Software version descriptions §§ 5.12.2, 5.13.3	a. Contains all *applicable* information in SVD *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Meets delivery *requirements*. h. Accurately identifies the version of each *software component,* i.e., file, unit, *software item*, delivered. i. Accurately identifies the changes incorporated. j. Accurately identifies the known *discrepancies*, errors, error avoidance, liens, and workarounds. k. Provides accurate installation instructions for each *user site*.
25.	Software user manuals § 5.12.3.1	a. Contains all *applicable* information in SUM *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Accurately describes software installation and use to the intended audience of this manual.
26.	Computer operation manuals § 5.12.3.2	a. Contains all *applicable* information in COM *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Accurately describes the operational characteristics of the *target computer system* and procedures for its operation. h. Does not duplicate information available in commercial manuals.
27.	Source files § 5.13.2	a. Contains all *applicable* information in SPS *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Meets delivery *requirements*. h. All required *software* is present. i. Shows evidence that the version of the *source code* exactly matches the version that passed *testing*. j. Deliverable media accurately labeled. k. Shows evidence that *source code* exactly matches the specific identified configuration-managed version of the *source code*. l. Consistent with the *software units* and data in the "as built" software *design*.
28.	"As built" software item design and related information § 5.13.4	a. Contains all *applicable* information in SPS *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Accurately describes the "as built" design of the *software item*.

ID	Product	Evaluation Criteria
		h. Accurately describes compilation and *build* procedures. i. Accurately describes modification procedures. j. Measured software resource utilization meets software item *requirements*.
29.	"As built" *system* and *subsystem design* § 5.13.5	a. Contains all *applicable* information in SSDD *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows systems engineering management plan and SDP, as *applicable*. g. Accurately describes the "as built" *system* and *subsystem design*.
30.	Computer programming manuals § 5.13.8.1	a. Contains all *applicable* information in CPM *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Accurately describes the programming features of the *target computer system*. h. Does not duplicate information available in commercial manuals.
31.	Firmware support manuals § 5.13.8.2	a. Contains all *applicable* information in FSM *DID*. b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Accurately describes *firmware* programming features. h. Does not duplicate information available in commercial manuals.
32.	Software measurement plan § 5.20.1	a. Contains all *applicable* information in SMP template (see Appendix H.4). b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Covers all required software measures. h. Covers all software measurement-related activities in the *SOW* and the SDP, SMP, and SMR *CDRL* items. i. Consistent with all software *requirements, builds, architecture*, *test* plans, critical computer resources, and *TPMs*. j. Provides insight into development with current data and explanations. k. Presents a sound approach to software measurements that will satisfy the management and technical information needs of the project.
33.	Software measurement report § 5.20.2	a. Contains all *applicable* information in SMR template (see Appendix H.5). b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable.

ID	Product	Evaluation Criteria
		e. Internally consistent. f. Follows SDP. g. Covers all required software measures. h. Covers all software measurement-related activities in the *SOW* and the SDP, SMP, and SMR *CDRL* items. i. Consistent with all software *requirements, builds, architecture, test* plans, critical computer resources, and *TPMs*. j. Provides insight into development with current data and explanations.
34.	Process improvement plan § 5.25	a. Contains all *applicable* information in PIP template (see Appendix H.6). b. Meets *SOW*, if *applicable*. c. Meets *contract*, if *applicable*. d. Understandable. e. Internally consistent. f. Follows SDP. g. Provides a sound approach to software process improvement on the project. h. Addresses all needed process improvement areas identified by the project's appraisals.
35.	Sampling of software development files §§ 5.1.2.1, 5.2.4, 5.6.3, 5.7.1, 5.7.2, 5.7.4, 5.7.5, 5.7.6, 5.8.2, 5.8.4, 5.8.5, 5.8.6, 5.9.6, 5.9.7, 5.9.8, 5.10.2, 5.10.4, 5.10.5, 5.10.6, 5.11.3, 5.11.6, 5.11.7, 5.11.8	a. Meets *SOW*, if *applicable*. b. Understandable. c. Internally consistent. d. Follows SDP. e. Contents are current with the ongoing effort. f. Adequate unit *test cases*, *procedures*, data, and results. g. Adequate unit integration *test cases*, *procedures*, data, and results. h Adequate software item qualification dry run results. i. Adequate software-hardware item integration *test cases, procedures*, data, and results. j. Adequate *system qualification* dry run results for *software-only systems*.

Appendix E. Joint Technical and Management Reviews

E.1 Scope

This appendix is a MANDATORY part of this standard. This appendix describes a set of joint technical reviews and joint management reviews that are held during a *software development* project.

Note 1: It is acceptable for any of these *joint reviews* to be held incrementally as agreed to by the *acquirer* and *developer*. Examples include covering all of the applicable topics for a *build*, covering a subset of the applicable topics for one or more *software items*, or any combination thereof.

Note 2: If a *software item* is developed in multiple *builds*, some of the software *products* will not be completed until the final *build*. For these reviews, the software *products* for each *build* are interpreted to include those parts of software *products* needed to meet the *requirements* to be implemented in the *build(s)* under review.

E.2 Joint Technical Reviews

Joint technical reviews consist of two types: software-specific joint technical reviews (see Section E.3) and joint technical reviews supporting major reviews (see Section E.4). The following *requirements* supplement the *requirements* specified in Section 5.18.1 for joint technical reviews.

1. The *developer* **shall** provide the *acquirer* a minimum of two weeks of advance notice of the exact time and location of:
   a. software-specific joint technical reviews, and
   b. joint technical reviews supporting major reviews.

Note: The *developer* and *acquirer* can mutually agree upon a different advance notification length of time.

E.3 Software-Specific Joint Technical Reviews

Note 1: If a *system* or *software item* is developed in multiple *builds*, the types of joint technical reviews held and the criteria applied depend on the objectives of each *build*.
Note 2: This section is written in terms of software build reviews. However, if the *system* or *software item* is developed using a once-through i.e., waterfall, lifecycle model, the following *requirements* apply with the interpretation that the *software* is developed as a single *build*.

1. The *developer* **shall** hold software-specific joint technical reviews for each *build*.
2. For each *build* the *developer* **shall** select and propose the software-specific joint technical reviews to be held for that *build*.
3. For each *build* the *developer* **shall** select from the following software-specific joint technical review candidates:
   a. Software Build Planning Review (SBPR),
   b. Software Build Requirements and Architecture Review (SBRAR),
   c. Software Build Design Review (SBDR),
   d. Software Build Test Readiness Review (SBTRR), and
   e. Software Build Exit Review (SBER).

   Note: The *developer* can propose additional or different software-specific joint technical reviews from the reviews specified above, if justified by the build objectives.
4. The *developer* **shall** *document* the following information in the SDP:
   a. The software-specific joint technical reviews to be held for each *build*,
   b. The rationale for selecting the software-specific joint technical reviews to be held for each *build*, and
   c. The objectives for each software-specific joint technical review selected, if different from the objectives specified in this appendix.

   Note 1: Different *builds* can have the same or different objectives for a particular type of

software-specific joint technical review. If they differ, the developer *should* specify the differences.

Note 2: The *developer may* tailor the build objectives for the reviews specified in this appendix or *may* define the build objectives for any additional or different software-specific joint technical reviews.

5. For each *build*, the *developer* **shall** define the following in the SDP for each selected software-specific joint technical review*:*
   a. Entrance criteria,
   b. Exit criteria,
   c. Products to be reviewed, and
   d. Mandatory attendees.
6. For each software-specific joint technical review, the *developer* **shall**:
   a. Document the action items generated during each software-specific joint technical review,
   b. Maintain the action item list, and
   c. Track the action items to closure.

   Note: Closure of an action item can result in, for example, the *issue* being resolved or a *discrepancy and change report (DCR)* being generated.
7. For each software-specific joint technical review, the *developer* **shall**:
   a. Review all open action items from previous reviews, and
   b. Describe plans for closure of those action items that are still open.
8. For each software-specific joint technical review, the *developer* **shall**:
   a. Review the objectives and exit criteria of previous software-specific joint technical reviews *applicable* to the *build(s)* under review,
   b. Determine whether any changes since the previous software-specific joint technical reviews have caused one or more objectives or exit criteria to no longer be satisfied,
   c. Discuss the impact of any unsatisfied prior objectives and exit criteria, and
   d. Describe plans for returning the unsatisfied prior objectives and exit criteria to a satisfied state.

   Note: Of particular importance are the objectives and exit criteria of the SBPR, since that review examines whether the allocated resources are sufficient to develop the build content on the required schedule. This resource and schedule issue needs to be re-examined in light of all changes that have happened since the previous SBPR.
9. The developer **shall** capture lessons learned to improve *processes* for future software-specific joint technical reviews.
10. The developer **shall** provide evidence to support the satisfaction of the software-specific joint technical review objectives and exit criteria.

    Note: Evidence, for example, can consist of part or all of the software *products* themselves, engineering analyses, trade studies, models, and simulations, as well as other types of analyses.
11. Each software-specific joint technical review **shall** have the following general objectives:
    a. Review evolving software *products*, using as minimum criteria the software product *evaluation* criteria in Appendix D;
    b. Review and *demonstrate* proposed technical solutions;
    c. Provide insight and obtain feedback on the technical effort;
    d. Surface and resolve technical *issues*;
    e. Surface near- and long-term *risks* regarding technical, cost, and schedule *issues*;
    f. Arrive at agreed-upon mitigation strategies for identified *risks*, within the authority of those present;
    g. Identify *risks* and *issues* to be raised at joint management reviews;
    h. Update the risk mitigation plans;
    i. Determine if software risk mitigation is proceeding according to the updated software risk mitigation plans; and

j. Provide for ongoing communication between *acquirer* and *developer* technical personnel.

E.3.1 Software Build Planning Review (SBPR)

This subsection provides the specific objectives for the Software Build Planning Review (SBPR). All objectives apply to the software *products* as completed for the *build(s)* under review. See Section E.3 for overall *requirements* that apply to all software-specific joint technical reviews.

1. The objectives of the SBPR **shall** be to *ensure* that:
   a. The *requirements* allocated to *software* and the overall software architectural *design* are sufficiently mature for accurate build planning.
   b. The software *processes*, including standards and procedures:
      (1) Are sufficiently defined, mature, and effective for performing the build *software development* activities;
      (2) Are suitable for the project scope and complexity;
      (3) Include lessons learned from use on previous *builds;* and
      (4) Are *documented* in the Software Development Plan.
   c. The overall build plan is:
      (1) Suitable for the project scope and complexity;
      (2) Suitable for meeting the needs and timing of the higher integration levels; and
      Note: Higher integration levels include, e.g., hardware-software integration, *subsystem* integration, and *system* integration.
      (3) Suitable for meeting the needs and timing of *contract* milestones.
      Note: Examples of software-related *contract* milestones are external interface *tests*, installation in *user sites*, and *turnover* to operations.
   d. The build content for the *build(s)* under review is clearly *defined* and *documented*, including:
      (1) The *requirements* allocated to the *build*,
      (2) The functions to be implemented in the *build*,
      (3) The architecture and design *components* to be implemented in the *build*, and
      (4) The *discrepancy and change reports* to be fixed in the *build.*
   e. The software *risks* for the *build(s)* under review:
      (1) Are complete and current, as of the time of the review;
      (2) Have well-defined, effective mitigation plans in place; and
      (3) Are being tracked to retirement.
   f. The resources allocated to the *build* are sufficient to develop the build content on its required schedule for each *build* under review.
   g. The impacts from previous *builds* and from external sources upon the *build(s)* under review remain manageable within the allocated build resources and schedule(s), including impacts from:
      (1) Unsatisfied *requirements* reallocated from previous *builds* to the *build(s)* under review;
      (2) Changes to the *requirements* allocated to the *build(s)* under review;
      (3) The *discrepancy and change reports* allocated to the *build(s)* under review;
      (4) Changes to the previously developed software *architecture*, *design*, and code; and
      (5) Newly identified software *risks* or known *risks* with increased impact or likelihood of occurrence.
   h. The resources allocated for the *build(s)* under review are sufficient to handle:
      (1) Overlapping build development; and
      (2) Support of higher-level integration and operations, as *applicable*.

i. Implementation of the *software engineering environment* is sufficiently mature to proceed with software and system development activities that will use these facilities, including the following aspects:
   (1) Software engineering tools for configuration management, *requirements*, *architecture*, *design*, coding, integration, debugging, and development *testing* are in place, or planned to be in place, by the time they are needed for the *build(s)* under review; and
   (2) The *software engineering environment*, in place or planned to be in place, has sufficient capability and capacity for concurrent *build(s)*.

j. Implementation of the *software integration and qualification test environment* is sufficiently mature to proceed with software and system development activities that will use these facilities, including the following aspects:
   (1) The *software integration and qualification test environment* is in place, or planned to be in place, by the time it is needed for the *build(s)* under review; and
   (2) The *software integration and qualification test environment*, in place or planned to be in place, has sufficient capability and capacity for testing the *build(s)* under review and the concurrent *builds* being developed, integrated, and fielded.

k. The SDP and software standards and procedures (e.g., work instructions) are adequate for the software development activities to be performed in the *build(s)* under review and for the program scope and complexity.

l. Personnel performing the software development activities for the *build(s)* under review are in place, fully trained, and proficient in the *applicable processes*, standards, and procedures.

m. The software *risks* for this *build* have been updated to include identification and assessment of new *risks* and reassessment of existing *risks*:
   (1) Updated software risk mitigation plans are in place, and
   (2) Software risk mitigation is proceeding according to the updated software risk mitigation plans.

n. Software size, effort, cost, schedule, and staffing estimates and actuals are realistic and appropriate for the *build(s)* under review.

o. The software measurements for the previous *build(s)*, if any, are realistic and within acceptable tolerances.

E.3.2 Software Build Requirements and Architecture Review (SBRAR)

This subsection provides the specific objectives for the Software Build Requirements and Architecture Review (SBRAR). All objectives apply to the software *products* as completed for the *build(s)* under review. See Section E.3 for overall *requirements* that apply to all software-specific joint technical reviews.

Note: All of the software requirements are specified in the Software Requirements Specification (SRS) and the Interface Requirements Specification (IRS). (See Section 6.2 for the SRS and IRS *DID* identifiers.)

1. The objectives of the SBRAR **shall** be to ensure that:
   a. The software *requirements,* including interface *requirements,* specialty engineering *requirements* (e.g., Human Systems Integration, information assurance, dependability), performance *requirements*, i.e., Key Performance Parameters, response time, and end-to-end timing *requirements,* are sufficiently mature to proceed with dependent software and system development activities, including the following aspects:
      (1) Higher level *requirements* allocated to *software* are complete and stable;
      (2) Software *requirements* are stable, correct, complete, consistent, feasible, verifiable, and clearly and unambiguously stated;
      (3) Software *requirements* have all TBXs resolved;

Note: TBXs include To be determined (TBDs), To be resolved (TBRs), and To be satisfied (TBSs).

(4) Software *requirements* include necessary *requirements* derived from the system and software *architecture*, system operational concepts, trade studies, and design decisions;

(5) Software *requirements* are fully bidirectionally traced to and from their *parent requirements* or to and from the source(s) from which they are derived;

(6) Software *requirements* include *requirements* for *off-nominal* and error *conditions;*

(7) Software interface *requirements* are agreed to by all parties;

(8) Software *requirements*:

(a) Have one or more valid *verification methods* and levels specified, and

(b) Are able to be fully verified by those methods and levels;

(9) Each software *requirement* is allocated to one or more software architecture *components*; and

(10) Software *requirements* are fully bidirectionally traced to and from the software architecture *components* by which they will be implemented.

b. The software *architecture* is sufficiently mature to proceed with dependent software and system development activities, including the following aspects:

(1) The software *architecture* is complete, stable, and valid;

(2) The software *architecture* is consistent:

(a) Internally among the software architecture *components*, and

(b) With the system *architecture* and operational concepts;

(3) The software architecture representations *document* the software architecture *components* and their *interfaces*, including:

(a) Internal *software*-to-*software* and *software*-to-hardware *interfaces*;

(b) External *software*-to-*software* and *software*-to-hardware *interfaces*; and

(c) Data and control in each of these interfaces.

(4) The software architecture representations cover multiple perspectives, including:

(a) Definition of logical architecture *components*, connectors, and *interfaces,* including their functionality, interactions, and dependencies;

(b) Definition of the conceptual and logical data schema for key data structures and their relationship to the software architecture *components* and algorithms;

(c) Definition of the software architecture component behaviors, interactions, and collaborations;
Note: Techniques such as sequence diagrams, activity diagrams, and state machines can be used here.

(d) Definition of the physical organization of the *software*, including the target processors on which the software architecture *components* execute; and

(e) Identification and definition of the *software units* and a mapping between the *software units* and the software architecture *components;*

(5) Analysis of software architecture and design decisions and tradeoffs is valid, appropriate to the project scope and complexity, and *documented*;

(6) *Evaluation* of *reusable software products*, including *commercial-off-the-shelf (COTS) software*, supports their selection for partially or fully implementing one or more software architecture *components*;

(7) The software *architecture* is able to support growth and change and adequately isolates implementation details to facilitate change; and

(8) The software *architecture* has been evaluated as capable of meeting its allocated software *requirements* (e.g., by engineering analyses, modeling, and simulation).

c. The software *qualification test* planning is sufficiently mature to proceed with dependent software and system development activities, including the following aspects:

(1) The software *qualification test* plan is complete, stable, and valid;

(2) The software *qualification test* plan is consistent with the higher-level test plans;
(3) The software *qualification test* plan is consistent with the qualification provisions for *verification methods* and levels in the Software Requirements Specification(s) and Interface Requirements Specification(s);
Note: The qualification provisions are found in Section 4 of the SRS and IRS *DIDs* (See Section 6.2 for the SRS and IRS *DID* identifiers.)
(4) All software *requirements*, including *interface* and specialty engineering *requirements*, are:
(a) Allocated to one or more tests in the Software Test Plan where they will be verified, and
(b) Bidirectionally traced to and from the tests described in the Software Test Plan;
(5) The *tests* in the Software Test Plan include *nominal*, *off-nominal*, and error *conditions*; and
(6) The software *requirements* will be fully verified by the *tests* described in the Software Test Plan, whether the *requirements* are implemented by *COTS software*, other *reusable software*, including unmodified or modified *reusable software*, or newly developed *software.*

d. Implementation of the *software integration and qualification test environment* is sufficiently mature to proceed with software and system development activities that will use these facilities, including the following aspects:
(1) The *software integration and qualification test environment* is in place, or planned to be in place, by the time needed for the *build(s)* under review;
(2) The *software integration and qualification test environment*, in place or planned to be in place, has sufficient capability and capacity for the testing of the *build(s)* under review;
(3) The *software integration and qualification test environment*, in place or planned to be in place, has all target hardware in a configuration as close to the operational configuration as possible; and
(4) The *software integration and qualification test environment* has actual interfacing equipment and systems, or *high-fidelity simulator(s)* in place, or planned to be in place, by the time needed.

E.3.3 Software Build Design Review (SBDR)

This subsection provides the specific objectives for the Software Build Design Review (SBDR). All objectives apply to the software *products* as completed for the *build(s)* under review. See Section E.3 for overall *requirements* that apply to all software-specific joint technical reviews.
Note: The software *requirements* are specified in the Software Requirements Specification (SRS) and the Interface Requirements Specification (IRS). (See Section 6.2 for the SRS and IRS *DID* identifiers.)

1. The specific objectives of the SBDR **shall** be to ensure that:
a. The software *design*, including the interface and database *design*, is adequate for meeting the software *requirements,* including interface *requirements,* specialty engineering *requirements* (e.g., Human Systems Integration, information assurance, *dependability*), performance *requirements* (Key Performance Parameters), response time *requirements*, and end-to-end timing *requirements*:
(1) The software *design* has been *demonstrated* to meet all allocated software *requirements*;
(2) The software *design* has been *demonstrated* to meet its allocated performance *requirements* with sufficient margin for this point in the lifecycle;
(3) The software *design* has been *demonstrated* to meet its computer resource allocations for CPU, memory, storage, and I/O bandwidth with sufficient margin for this point in the lifecycle;

(4) All software *requirements* are allocated to software design *components* down to the software unit level; and
(5) All software *requirements* are bidirectionally traced to and from software design *components* down to the software unit level.

b. The software *design*, including the interface and database *design*, is consistent with the system and software *architectures*.
c. The software *design,* including the interface and database *design*, is sufficiently mature to proceed with the build's dependent software and system development activities, including software implementation, integration, and *test* activities:
(1) The software *design* for the *build* has been elaborated to the level of *software units*, consistent with the SDP and the selected software lifecycle model(s);
(2) Software design decisions and their tradeoffs, including justifications for *COTS* and *reusable software* selections using *evaluation* criteria, were adequately analyzed and recorded;
(3) Each of the build's *software units* is identified as containing *COTS*, unmodified reuse, modified reuse, or newly developed *software*, or a combination thereof.
(4) For each of the build's *software units* containing *COTS*, unmodified reuse, or modified reuse *software*, the source of that *software* is identified.
(5) COTS products were evaluated and selected for implementing software architecture *components* and all tradeoffs, selections, installation, and configuration design decisions are recorded;
(6) Detailed software interface definitions are managed by Interface Design Documents (IDDs) or Interface Control Documents (ICDs) and agreed to by all parties; and
(7) The *software*, *database*, and *interface* design descriptions are clear, correct, complete, consistent, and unambiguous, and adequately address:
(a) Detailed *design* of all external and internal *interfaces*;
(b) Detailed *design* of all files, *databases*, shared memory, etc., and their storage and access methods;
(c) Detailed *design* of user interface screens and human system interactions if *applicable*;
(d) Detailed *design* of algorithms for the build's *software units*, including mathematical and procedural algorithms;
(e) Detailed *design* of the dynamic structure of the build's *software* (e.g., processes or tasks, flow of execution control, priorities, sequencing, dynamic creation and deletion of processes or tasks);
(f) Detailed *design* of glue code for integrating the *COTS* and other *reusable software* with the rest of the *software;*
(g) Detailed *design* of fault management and recovery methods, including safe mode for onboard *software*, exception handling, error handling, and operator notification of errors; and
(h) Application programming interfaces to be used.
d. The software detailed *design* is consistent with all *applicable* standards (e.g., interface, screen design, and open systems standards).
e. The software *processes,* including coding and testing standards, are sufficiently *defined*, mature, and effective for developing the *software* needed to meet the *requirements* and are suitable for the program scope and complexity, including:
(1) The selected programming language(s) to be used have been evaluated, justified, and *recorded*; and
(2) The coding standards to avoid vulnerabilities and facilitate *maintenance* are *defined* and *recorded*.

f. The software item *qualification test* plans and *cases* are sufficient to ensure thorough *nominal* and *off-nominal testing* of the *software* to *demonstrate* that the software *requirements* are verified in the target environment:
   (1) The software item *qualification test cases* in the Software Test Description (STD) are valid, complete, stable, and consistent with the software *architecture* and *design* and Software Test Plan (STP);
   (2) The software item *qualification test cases* are consistent with the qualification provisions for *verification methods* and levels specified in the Software Requirements Specification(s) and Interface Requirements Specification(s);
   Note: The qualification provisions are found in Section 4 of the SRS and IRS *DIDs*. (See Section 6.2 for the SRS and IRS *DID* identifiers.)
   (3) The software *requirements,* including interface *requirements,* are bidirectionally traced to and from *qualification test cases* described in the STD;
   (4) All software *requirements,* including interface *requirements,* are allocated to the *test cases* described in the STD where they will be verified;
   (5) The software *requirements*, including interface *requirements,* will be fully verified by the *test cases* described in the STD, whether they are implemented by *COTS software*, other *reusable* modified or unmodified software, or newly developed *software*; and
   (6) The test cases in the STD include *verification* of all software *requirements,* including interface *requirements,* under *nominal*, *off-nominal*, and error *conditions*.

g. The *software engineering environment* and *software integration and qualification test environment* are established and have adequate capability and capacity to meet the software development, integration, and verification *requirements* and schedules, including multiple concurrent *builds*:
   (1) Integration and *qualification test* facilities, including target hardware in a configuration as close to the operational configuration as possible, and actual interfacing equipment and systems, or *high-fidelity simulators*, for development, integration, and qualification testing are in place, or planned to be in place in time.

h. The software *requirements*, *architecture*, *design*, *qualification test* plans and *test cases*, and the software master build plan are correct, consistent, complete, traceable, contain no TBXs, and are supported by engineering analyses.

E.3.4 Software Build Test Readiness Review (SBTRR)

This subsection provides the specific objectives for the Software Build Test Readiness Review (SBTRR). All objectives apply to the software *products* as completed for the *build(s)* under review. See Section E.3 for overall *requirements* that apply to all software-specific joint technical reviews.

1. The objectives of the SBTRR **shall** be to ensure that:
   a. The *software* under *test* is sufficiently mature to begin the formal *qualification test* event:
      (1) The *software* under *test* is under configuration control by the software configuration management organization;
      (2) The *software* under *test* is clearly defined in the Software Version Description (SVD);
      (3) All known problems with the *software* are documented in *discrepancy and change reports* (*DCRs)*;
      (4) No severity 1 or 2 *DCRs* are open for the *software* under *test*; and
      (5) The impacts of any open *DCRs* on the test execution are known, and workarounds for affected procedures are *documented* and in place.
   b. The software item *qualification test* plans, test *cases*, *test procedures, test data,* and *test databases* are under configuration control by the software configuration management organization.
   c. The software item *qualification test* plans, *cases*, and *procedures* are correct, consistent, complete, and traceable to the software and interface *requirements:*

(1) The software item *test* plan, *test cases*, and *test procedures* in the STP and STD, including all changes to the software *requirements*, test plan, and *test cases* since the SBDR, are correct, consistent, complete, and traceable to the software and interface *requirements* (SRS, IRS).
Note: The software *requirements* are specified in the Software Requirements Specification (SRS) and the Interface Requirements Specification (IRS). (See Section 6.2 for the SRS and IRS *DID* identifiers.)

(2) The *test procedures*:
   (a) Include testing of both *nominal* and *off-nominal conditions;*
   (b) Include procedures for test setup, test execution, data capture, and data analysis;
   (c) Include *bidirectional traceability* between the software and interface *requirements* and the *test procedure* step where the *requirements* are verified;
   (d) Are sufficient to verify all of the *requirements* allocated to the *test case*;
   (e) Are consistent with the *verification methods* and levels in the SRS and IRS for each *requirement*;
   (f) Are sufficiently detailed to be repeatable; and
   (g) Are automated to the extent feasible.

(3) No changes to the software *architecture* or *design* since the SBDR have affected the *test cases* and *test procedures* for this test event.

d. Test management *processes* and procedures are in place to ensure that:

(1) The *processes* to be followed during the test execution are *defined* and *documented* and will result in a controlled and disciplined test execution, including:
   (a) The *processes* for initial testing, retesting, and *regression testing*; and
   (b) The *process* for *discrepancy* adjudication to determine whether and how *testing* can be continued after a *discrepancy* has occurred during execution.

(2) Personnel roles and responsibilities are well defined for *developer*, *acquirer*, and *acquirer* support personnel.

(3) Sufficient time on the *software integration and qualification test environment* is available for the *qualification test* event to execute all *test procedures* without schedule compression, including sufficient schedule margin for retesting.

(4) The test schedule is feasible for the test execution to be performed.

(5) Software quality assurance personnel are present to ensure that:
   (a) The *test processes* are followed;
   (b) The *test procedures* are executed;
   (c) Any deviations from the *test procedures* or test results are documented as *redlines*;
   (d) All problems and *discrepancies* are *documented* in *DCRs*; and
   (e) The test log completely and accurately *documents* the *test* execution, including test start, test end, interruptions, and *discrepancies.*
   Note: See Appendix F for test log *requirements*.

e. The *software, test procedures,* and test data have been successfully dry run:

(1) The software item *qualification test procedures* include both *nominal* and *off-nominal conditions*, and both *nominal* and *off-nominal conditions* have been successfully dry run with the *expected results*;

(2) The software item *qualification test procedures* have been successfully dry run in the *software integration and qualification test environment* using established test data:
   (a) The *test procedures* have been successfully dry run, and the *redlines* from the dry run have been incorporated into the *test procedures*; and
   (b) Any problems or *discrepancies* encountered during the procedure dry runs have been captured in *DCRs;*

(3) The software item *qualification test procedures* were able to verify their allocated software and interface *requirements* with their *expected results* in the *software integration and qualification test environment*; and
(4) Disciplined test *processes* are in place, and all necessary test resources, including test personnel and the *software integration and qualification test environment,* are available.

f. The *software integration and qualification test environment* is ready for the formal *qualification test* event to begin:
(1) The *software integration and qualification test environment* is clearly defined and is under configuration control by the software configuration management organization, including:
(a) both the hardware and *software*, including test tools and *high-fidelity simulators*, and
(b) all test data and *test databases*;
(2) The *software integration and qualification test environment* , including the test data and *databases*, is sufficient to adequately verify the software and interface *requirements*;
(3) The *software integration and qualification test environment* has undergone sufficient *validation* to ensure all items in the test environment, including hardware, *software*, and *high-fidelity simulator(s),* correctly perform the functions necessary to support the *qualification test* event; and
(4) The *software integration and qualification test environment* is fully representative of the operational environment including;
(a) Operational hardware and software configurations, operational data rates, and operational scenarios;
(b) Hardware-in-the-loop testing for software and system *testing*; and
(c) *Software* in the loop for hardware and system *testing*.

E.3.5 Software Build Exit Review (SBER)

This subsection provides the specific objectives for the Software Build Exit Review (SBER). All objectives apply to the software *products* as completed for the *build(s)* under review. See Section E.3 for overall *requirements* that apply to all software-specific joint technical reviews.

1. The specific objectives of the SBER **shall** be to ensure that as completed for this *build*:
a. The updated software *requirements*, *architecture*, and *design,* remain valid, complete, consistent, stable, and traceable, including:
(1) *Bidirectional traceability* is maintained between the software and interface *requirements* in the SRS and IRS and the:
(a) Software architecture and design *components*, and
(b) Software item *qualification test cases* and *test procedure* steps.
b. The software unit integration and regression *test* plans, *cases*, and *procedures* are correct, complete, consistent, stable, traceable, repeatable, address both *nominal* and *off-nominal conditions*, and were successfully executed for the *build* under review:
(1) Build integration and build regression test results were *documented* in *software development files (SDFs)*, and
(2) Build *regression testing* has ensured that the *build* under review had no adverse effects on functions successfully developed and tested in previous *build(s)*).
c. The software item *qualification test* plan, *cases*, and *procedures* are correct, complete, consistent, stable, traceable, repeatable, address both *nominal* and *off-nominal conditions*, and were executed successfully, including:
(1) Software item *qualification test* results were *documented* in the Software Test Report (STR), including:

(a) Test logs,
(b) As-run *redlined test procedures* corrected to be as run,
(c) Results of data capture and analysis,
(d) Problems encountered,
(e) *DCRs* opened,
(f) *regression testing*, and
(g) retesting.

Note: Retesting and regression testing are recorded in the test log portion of the STR.

d. All problems have been *documented* in *DCRs* and categorized for severity:
   (1) All severity 1 and 2 problems have been resolved,
   (2) Retests have been successfully executed,
   (3) The results have been *documented,* and
   (4) All open severity 3 problems have been dispositioned and assigned to future *builds* for resolution.
e. The software requirements verification status, i.e., fully verified, partially verified, not verified:
   (1) is being maintained for each SRS and IRS *requirement*, and
   (2) is in an up-to-date condition following software item *qualification testing.*
f. All SRS and IRS *requirements* that were scheduled for *verification* in this *build* but were not verified have been assigned to a future *build* for completion.
g. The *software* is sufficiently tested to proceed with dependent software, hardware, and system integration and test activities.
h. The software *risks* for the *software* in this *build* have been updated to include identification and assessment of new *risks* and reassessment of existing *risks* as a result of the completion of this *build*:
   (1) Updated software risk mitigation plans are in place, and
   (2) Software risk mitigation is proceeding according to the updated software risk mitigation plans.
i. Software size, effort, cost, schedule, and staffing estimates and actuals were updated following this *build* and are consistent with the build results.
j. The Software Master Build Plan (SMBP), including the build schedule, remains executable for future *build(s)*, considering:
   (1) The increased knowledge of the software *requirements*, *architecture*, *design*, *implementation*, test plans, *test cases*, *test procedures*, and test results;
   (2) The identified software *risks;*
   (3) The updated software size, effort, cost, schedule, and staffing estimates remain consistent with the build results; and
   (4) The adequacy of any updates to the SMBP since the SBDR and SBTRR, such as new *DCRs* allocated to the future *builds* or software *requirements* not satisfied by this and previous *builds* slipping to future *builds.*
k. The SDP and software standards and procedures (e.g., work instructions) are still adequate for the *software development* activities to be performed in future *builds* and for the program scope and complexity, including any changes made since the SBDR and SBTRR.
l. If this *build* is scheduled for delivery to the operational environment, the following are satisfied:
   (1) Adequate training has been performed for operations personnel;
   (2) The *software* is sufficiently mature for operations (e.g., the number of workarounds to handle open severity 3 *DCRs* is small enough that the operators can still perform their tasks within their required response times);
   (3) The *software* is ready for installation at *user sites*;
   (4) The user and operator manuals are complete for this *build*;

(5) The software version descriptions are complete for this *build*; and
(6) The software installation preparations, activities, and instructions are complete for this *build.*

m. If this *build* is scheduled for delivery to the *maintenance* environment, the following are satisfied:
(1) The sustainment *products* are correct and complete:
(a) The software product specifications, and
(b) The software version descriptions;
(2) The *software transition* to maintenance preparations, activities, and instructions are complete for this *build*;
(3) The *software* is sufficiently mature for simultaneous operations and maintenance:
(a) e.g., the number of workarounds to handle open severity 3 *DCRs* is small enough that the operators can still perform their tasks within their required response times; and
(b) e.g., the number of maintenance and development personnel can support both maintenance and support anomalies or user problems in operations;
(4) The resources for sustainment are adequate and in place;
(5) The training has been adequate for sustainment personnel;
(6) The *transition* of the *software engineering environment*, if *applicable*, is complete; and
(7) The *maintenance organization* is ready to begin *maintenance*.

n. Based on all of the above criteria, the software is sufficiently mature to consider this *build* completed.

E.4 Joint Technical Reviews Supporting Major Reviews

Note: Major reviews include system-level reviews such as System Requirements Review (SRR), System Design Review (SDR), System Functional Review (SFR), Software Requirements and Architecture Review (SAR), Preliminary Design Review (PDR), Critical Design Review (CDR), and Test Readiness Review (TRR). One set of requirements for major reviews can be found in (Peresztegy 2009-1) and (Peresztegy 2009-2).

1. If a major review is required by the *contract* and its scope includes *software*, then a software joint technical review **shall** be held to assess the technical readiness of the software *products* and other materials prior to the major review.
2. The software joint technical review **shall** be held sufficiently in advance of the major review so that identified problems and *issues* can be resolved before the delivery of *products* and other materials in support of the major review.

E.5 Joint Management Reviews

The following requirements supplement those in Section 5.18.2 for joint management reviews.

E.5.1 Joint Management Review Frequency

1. The developer **shall** hold periodic joint management reviews:
   a. At a frequency agreed to by the *acquirer* and *developer* or as specified by the *contract*, and
   b. At least quarterly.
2. The developer **shall** hold joint management reviews on an event-driven basis:
   a. Prior to software-related project milestones as specified by the *contract* or as agreed to by the *acquirer* and *developer*;
   b. Following the joint technical review that precedes each major review, or in combination with that joint technical review (see Section E.4), and
   c. For software issues that need to be addressed between the periodic joint management reviews, as agreed to by the *acquirer* and *developer.*

E.5.2 Joint Management Review Topics

1. The software management products in Table E.5-1 **shall** be reviewed at each joint management review:
   a. Upon initial definition of the *product*, and
   b. For any changes or updates to the *product*.
2. The joint management reviews **shall** also address the following items:
   a. Open technical issues in the software *products* and activities, and
   b. Technical *risks* that are new or changed.

Table E.5-1 Software Management Products

ID	Software Management Products
1.	Software-related plans
2.	Software estimates
3.	Integrated schedules
4.	Analysis of impacts from entities external to the *build(s)* or *software item(s)* under review
5.	Identified software-related risks and risk handling status
6.	Identified *discrepancy and change reports* (*DCRs*) and status
7.	Open software-related issues and status
8.	Action items status for action items related to software
9.	Software *requirements* verification status
10.	Software-related *product* status
11.	Software-related process execution status
12.	Current software measurement reports, including interpretations of the latest measurement values and trends
13.	Software configuration management status
14.	Software quality assurance status, including noncompliance reports and status
15.	Status of procurement, development, and maintenance of the software-related management environment, *software engineering environment,* and *software integration and qualification test environment*.
16.	Analysis of impacts on entities external to the *build* under review

Appendix F. Test Log Requirements

F.1 Scope

This appendix is a MANDATORY part of this standard. This appendix identifies the minimum information that is required for test logs.

F.2 Test Logs

F.2.1 Test Log Definitions

1. If the *developer* has alternative definitions for the test log terms defined in Section F.2.1, then the *developer* **shall** provide the definitions of those terms in the Software Development Plan (SDP).

The test log terms that apply to integration testing and *qualification testing* are defined below in alphabetical order.

Note: The *developer* may record additional information in test logs at any level of integration and *qualification testing*.

Description of *test incident*. A description of how the *test* deviated from the defined *test procedure* or *expected results* for example, inconsistencies between the *documented expected results* compared to the actual results; an error in the *test procedure* or *test* script; missing or failed *test* equipment or simulators; incorrect configuration of *test* equipment or simulators.

Description of *test interruption*. A description of why or how the test activity or test procedure was interrupted. See Section 3.1 definition of *test interruption* for examples.

List of *discrepancy and change report* identifiers. References to the identifier(s) of the *discrepancy and change report(s)* (*DCRs*) that were written as a result of the *discrepancy* or *test incident* on:
1. the *software* under *test*,
2. the *test cases and test procedures,* or
3. the *test* environment.

Note: These *DCRs* usually have mechanisms to provide additional information or attachments that can help identify the cause of the *discrepancy* or *test incident*.

List of witnesses. The names and organizations of the witnesses present for the *test procedure*.

Start time of the *test interruption.* Wall clock time, including the date and time zone of the start of the particular *test interruption*.

Start time of the test procedure(s). Wall clock time, including the date and time zone of the start of the particular *test procedure,* or set of *test procedures* if they are automated.

Stop time of the *test interruption.* Wall clock time, including the date and time zone of the end of the particular *test interruption*.

Stop time of the test procedure(s). Wall clock time, including the date and time zone of the end of the particular *test procedure,* or set of *test procedures* if they are automated.

Test procedure name or identifier. The name or identifier of the *test procedure*, and if *applicable*, the step in the *test procedure*.

F.2.2 Test Log Requirements

1. The *developer* **shall** produce a test log for each of the following activities:
   a. Unit integration and *testing* (Section 5.8),
   b. *Software item qualification testing* (Section 5.9),
   c. Software-hardware item integration and testing (Section 5.10), and
   d. System *qualification testing* (Section 5.11).
2. The *developer* **shall** include in the test log, as a minimum, the following information for each testing activity listed above:
   a. *Test procedure* name or identifier;
   b. Start time of the *test procedure(s)*;
   c. Stop time of the *test procedure(s)*;
   d. Description of *test interruption*, if any;
   e. Start time of the *test interruption*, if any;
   f. Stop time of the *test interruption*, if any;
   g. Description of *test incident*, if any;
   h. Start time of the *test incident*, if any;
   i. Stop time of the *test incident*, if any;
   j. List of *discrepancy and change report* identifier(s), if any; and
   k. List of witnesses (only required for qualification testing).
3. The *developer* **shall** include in the test log, explicitly or by reference to configuration controlled *documentation*, a description of the *test* environment that includes, as a minimum:
   a. Identification of all hardware by manufacturer, model, type, serial number, detailed configuration, and, if *applicable*, calibration date(s);
   b. Identification of all operating systems in use by name, version, and release;
   c. Identification of all *software* in use by name, version, and release;
   d. Identification of all simulators and emulators by name, version, and release;
   e. Identification of all *databases* used by name, version, and release;
   f. Identification of all specialized test equipment by name, model, and detailed configuration; and
   g. Identification of all other pertinent environmental conditions required to perform the testing.

Appendix G. Reserved

Appendix H. Product Templates

Scope

This appendix is a MANDATORY part of this standard. This appendix provides templates for several *documents.* See Section 6.2 for *DID* identifiers to be used with these templates.

The content of each template is consistent with the *requirements* of this standard. The templates included in this appendix are as follows:

H.1 Software Development Plan (SDP)
H.2 Software Architecture Description (SAD)
H.3 Software Master Build Plan (SMBP)
H.4 Software Measurement Plan (SMP)
H.5 Software Measurement Report (SMR)
H.6 Process Improvement Plan (PIP)

H.1 Software Development Plan (SDP) Template

This appendix is a MANDATORY part of the (SDSMCS). It provides the content *requirements* for the SDP.

1. Referenced information cited in paragraphs 4, 5, 6, and 7 **shall** be provided as attachments to the plan.
2. If the section numbering used below is not used, the *developer* **shall** provide an appendix in the SDP with a traceability matrix mapping from the section numbers and titles below to the section numbers and titles used in the *developer's* SDP.
3. If there is such a traceability mapping appendix, it **shall** be referenced in section 1.3.

   Note 1: The numbering shown in paragraphs 4 and 5 below is consistent with the Software Development Standard for Mission Critical Systems (SDSMCS).

Purpose. The Software Development Plan (SDP) describes a developer's plans for conducting a software development effort. The term "*software development*" is meant to include the new development, modification, reuse, *reengineering*, incorporation of commercial item (also known as *COTS*) packages, maintenance, and all other activities resulting in software *products*. The SDP provides the *acquirer* insight into, and a tool for monitoring, the *processes* to be followed for *software development*; the methods to be used; the approach to be followed for each activity; and project schedules, organization, and resources.

References

(CMMI) Software Engineering Institute, *Capability Maturity Model Integration, Version 1.3, CMMI for Development*, Report No. CMU/SEI-2010-TR-033, November 2010, Software Engineering Institute, Carnegie Mellon University. Capability Maturity Model® and CMMI® are registered in the U. S. Patent and Trademark Office by Carnegie Mellon University.

(SMS) Abelson, L. A., S. Eslinger, M. C. Gechman, C. H. Ledoux, M. V. Lieu, K. Korzac, *Software Measurement Standard for Mission Critical Systems*, Aerospace Report No. TOR-2009(8506)-6, 5 May, 2011, The Aerospace Corporation.

(SDSMCS) Adams, R. J., S. Eslinger, K. L. Owens, J. M. Tagami, and M. A. Zambrana, *Software Development Standard for Mission Critical Systems (SDSMCS)*, Aerospace Report No. TR-RS-2015-00012, March 17, 2014, The Aerospace Corporation. This is the same as SMC Standard SMC-S-012, *Software Development Standard*.

Content Requirements

This template contains the required content of the Software Development Plan (SDP). See Section 3 of the Software Development Standard for Mission Critical Systems (SDSMCS), Aerospace Report No. TOR-2013-00083, for definitions of all italicized words or phrases.

1. Scope. This section **shall** be divided into the following paragraphs.

1.1 Identification. This paragraph **shall** contain a full identification of the *system* and the *software* to which this *document* applies, including, as *applicable*, identification number(s), title(s), abbreviation(s), version number(s), and release number(s).

1.2 System overview. This paragraph **shall** briefly state the purpose of the *system* and the *software* to which this *document* applies. It **shall**: a) describe the general nature of the *system* and *software*; b)

summarize the history of system development, operation, and maintenance; c) identify the project sponsor, *acquirer*, *user*, *developer*, and support organizations; and d) identify current and planned operating and *user sites*.

1.3 Document overview. This paragraph **shall** summarize the purpose and contents of this *document*. This paragraph **shall** describe any *security* or privacy considerations associated with its use.

1.4 Relationship to other plans. This paragraph **shall** describe the relationship, if any, of the SDP to other project management plans.

2. Referenced documents. This section **shall** list the number, title, revision, and date of all *documents* referenced in this plan. This section **shall** also identify the source for all *documents* not available through normal Government stocking activities.

3. Overview of required work. This section **shall** be divided into paragraphs as needed to *establish* the context for the planning described in later sections. It **shall** include, as *applicable*, an overview of:
    a. *Requirements* and constraints on the *system* and *software* to be developed,
    b. *Requirements* and constraints on project documentation;
    c. Position of the project in the *system* lifecycle;
    d. The selected project and acquisition strategy;
    e. Any *requirements* or constraints on the selected project and acquisition strategy;
    f. *Requirements* and constraints on project schedules and resources; and
    g. Other requirements and constraints, such as on project *security*, privacy, methods, standards, interdependencies on hardware and *software development*.

4. General requirements. Provisions corresponding to nonrequired activities may be satisfied by the words "Not applicable." If different *builds* or different *software* on the project require different planning, these differences **shall** be noted in the paragraphs. See Section 4 in the body of the Software Development Standard for Mission Critical Systems (SDSMCS) for the activities and topics to be addressed in this leading paragraph. This section **shall** be divided into the following paragraphs. In addition to the content specified below, each paragraph **shall** identify *applicable* risks and uncertainties and plans for dealing with them.

4.1 Software development process. This paragraph **shall** describe the *software development process* to be used. The planning **shall** cover: a) identification of the *software development lifecycle model(s)* to be used; b) planned *builds*, if *applicable*; c) their build objectives; and d) the software development activities to be performed in each *build*. See Section 4.1 in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph.

4.2 General requirements for software development. See Section 4.2 and its subsections in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on *software development*. This paragraph **shall** be divided into the following subparagraphs.

4.2.1 Software development methods. This paragraph **shall** describe or reference the software development methods to be used. This paragraph **shall** include descriptions of the manual and automated tools and procedures to be used in support of these methods. Reference may be made to other paragraphs in this plan if the methods are better described in context with the activities to which they will be applied. See Section 4.2.1 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on software development methods.

4.2.2 Standards for products. This paragraph **shall** describe or reference the standards to be followed for representing *requirements*, *architecture*, *design*, code, *test cases*, *test procedures*, test results, *test* logs, and *discrepancy and change reports*. The standards **shall** cover all *contractual requirements* concerning standards for *products*. Reference may be made to other paragraphs in this plan if the standards are better described in context with the activities to which they will be applied. See Section 4.2.2 in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on standards for software *products*.

The contents of Paragraph 4.2.2 **shall** be placed into separate appendices of the SDP, not in Paragraph 4.2.2. Paragraph 4.2.2 **shall** reference these appendices.

4.2.2.1 Standards for code. Standards for code **shall** be provided for each programming language to be used. The coding standards for each language **shall** include, as a minimum:

a. Standards for format (such as indentation, spacing, capitalization, and order of information);
b. Standards for header comments, requiring, for example, name and identifier of the code; version identification; modification history; purpose; *requirements* and *design* decisions implemented; notes on the processing (such as algorithms used, assumptions, constraints, limitations, and side effects); and notes on the data (e.g., inputs, outputs, variables, data structures);
c. Standards for other comments, such as required number and content expectations);
d. Naming conventions (e.g., for constants, types, variables, parameters, packages, procedures, classes, objects, methods, functions, files);
e. Restrictions, if any, on the use of programming language constructs or features; and
f. Restrictions, if any, on the complexity of code aggregates.

4.2.2.2 Standards for DCRs. Standards for *discrepancy and change reports* (*DCRs*) **shall** be provided. The *DCR* standards **shall** include, as a minimum:

a. A glossary and definitions of terms that can be used in *discrepancy and change reports* (*DCRs*), including all specialized terms used in *DCR* titles, descriptions, causes, and resolutions;
b. Alternative and additional definitions, if any, for *DCR* terms specified in Appendix C.2.1 of this standard;
c. A *DCR* acronym list that includes all acronyms that are used (or are permitted to be used) in *DCRs.* These acronyms might appear in (e.g., *DCR* titles, free text descriptions of *test incidents*, *discrepancies*, failures, causes, resolutions, and development, integration and qualification test activity names);
   Note: This *DCR* acronym list is in addition to the acronym list for the entire SDP.
d. A list of activity names and their definitions used for *DCRs* besides those in Appendix C, Table C.2-2, of the standard; and
e. The names and sequence of the *DCR* steps that can be used.

4.2.2.3 Standards for test logs. Standards for test logs **shall** be provided. The test log standards **shall** include, as a minimum:

a. The test log fields and terms specified in Appendix F.2 of (SDSMCS); and
b. Alternative and additional definitions, if any, for test log terms specified in Appendix F.2.1 of (SDSMCS).

4.2.3 Traceability. This paragraph **shall** describe the approach to be followed for establishing and maintaining *bidirectional traceability* between levels of *requirements*, between *requirements* and *design*, between *design* and the *software* that implements it, between *requirements* and *qualification test* information, and between *computer hardware* resource utilization *requirements* and measured computer hardware resource utilization. See Section 4.2.3 in the body of (SDSMCS) for the activities, topics, and other items to be addressed in this paragraph on *bidirectional traceability*.

4.2.4 Reusable software products. See Section 4.2.4 in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on *reusable software products*. This paragraph **shall** be divided into the following subparagraphs.

4.2.4.1 Incorporating reusable software products. This paragraph **shall** describe the approach to be followed for identifying, evaluating, and incorporating *reusable software products*, including the scope of the search for such *products* and the criteria to be used for their *evaluation*. Candidate or selected *reusable software products* known at the time this plan is prepared or updated **shall** be identified and described, together with benefits, drawbacks, alternatives considered, rationale for those selected, remaining viable alternatives, and restrictions, as *applicable*, associated with their use.

4.2.4.2 Developing reusable software products. This paragraph **shall** describe the approach to be followed for identifying, evaluating, and reporting opportunities for developing *reusable software products*.

4.2.5 Assurance of critical requirements. See Section 4.2.5 in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on assurance of critical *requirements*. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for handling *requirements* designated critical.

4.2.5.1 *Safety*
4.2.5.2 *Security*
4.2.5.3 *Privacy protection*
4.2.5.4 *Reliability, maintainability,* and *availability*
4.2.5.5 *Dependability*
4.2.5.6 Human system integration, including *human factors engineering* and
4.2.5.7 Assurance of other mission-critical *requirements* as agreed to by the *acquirer* and *developer*

4.2.6 Computer hardware resource utilization. This paragraph **shall** describe the approach to be followed for allocating *computer hardware* resources and monitoring their utilization. See Section 4.2.6 in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on computer hardware resource utilization.

4.2.7 Recording rationale. This paragraph **shall** describe the approach to be followed for recording rationale that will be useful to the support organization for key decisions made on the project. It **shall** interpret the term “key decisions” for the project. It **shall** state where the rationale are to be recorded. See Section 4.2.7 in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on recording rationale.

4.2.8 Access for acquirer review. This paragraph **shall** describe the approach to be followed for providing the *acquirer* and its authorized representatives access to *developer* and *software team member* facilities for review of *products* and activities. It **shall** cover all *contractual requirements* concerning *acquirer* team access for review. See Section 4.2.8 in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on access for *acquirer* review.

4.2.9 Contractual requirements. This paragraph **shall** describe the approach to be followed for meeting all the *contractual requirements* regarding *software development*, including *testing*, *transition*, *maintenance*, and operations. Reference may be made to other paragraphs in this plan if the approach to be followed for meeting *contractual requirements* is better described in context with the activities to which they will be applied. These *contractual requirements* can be found in, e.g., the *Statement of Work (SOW)*, *Contract Data Requirements List (CDRL)*, compliance documents and their tailoring, Integrated Master Plan (IMP), specifications, Section H of the Model *Contract* (Sections A-K of the RFP and Contract), and other *contractual documentation*.

5. Plans for performing detailed software development activities. The paragraphs below cover the plans for performing detailed software development activities. Provisions corresponding to nonrequired activities may be satisfied by the words "Not applicable." If different *builds* or different *software* on the project require different planning, these differences **shall** be noted in the paragraphs. If different planning is required for new development, modification, *reusable software products*, *reengineering*, and *maintenance*, these differences **shall** be described in the paragraphs. The discussion of each activity **shall** include the approach, i.e., plans, *processes*, methods, procedures, tools, roles, and responsibilities, to be applied to: 1) the analysis or other technical tasks involved, 2) the recording of results, and 3) the preparation of associated deliverables, if *applicable*. For each activity, include a) entrance criteria, b) inputs, c) tasks to be accomplished, d) *products* to be produced, e) *verifications* to be used to ensure tasks are performed according to their defined *processes* and *products* meet their *requirements*, f) outputs, and g) exit criteria. The discussion **shall** also identify *applicable* risks and uncertainties and plans for dealing with them. Reference may be made to paragraph 4.2.1 if *applicable* methods are described there. This section **shall** be divided into the following paragraphs.

5.1 Project planning and oversight. See Section 5.1 and its subparagraphs in the body of the Software Development Standard for Mission Critical Systems (SDSMCS) for the activities and topics to be addressed in this paragraph on project planning and oversight. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for project planning and oversight.

- 5.1.1 Software development planning
- 5.1.2 Software integration and test planning
  - 5.1.2.1 Software integration planning
  - 5.1.2.2 Software item qualification test planning
- 5.1.3 System qualification test planning
- 5.1.4 Planning for *software transition* to operations
- 5.1.5 Planning for *software transition* to *maintenance*
- 5.1.6 Following and updating plans

5.2 Establishing a software development environment. The *developer* **shall** *record* the results of the *software engineering environment* adequacy analysis in the SDP. The *developer* **shall** *record* the results of the *software integration and qualification test environment* adequacy analysis in the SDP. See Section 5.2 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on establishing and maintaining software development environments. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for establishing, controlling, and maintaining a software development environment.

- 5.2.1 *Software engineering environment*
  - 5.2.1.1 *Software engineering environment* description
  - 5.2.1.2 *Software engineering environment* adequacy analysis reports
- 5.2.2 *Software integration and qualification test environment*
  - 5.2.2.1 *Software integration and qualification test environment* description

5.2.2.2 *Software integration and qualification test environment* adequacy analysis reports
5.2.3 *Software development library*
5.2.4 *Software development files*
5.2.5 *Nondeliverable software*

5.3 System requirements analysis. See Section 5.3 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on system requirements analysis. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for participating in system requirements analysis.
5.3.1 Analysis of *user* input
5.3.2 Operational concept
5.3.3 System *requirements* definition

5.4 System architecture and design. See Section 5.4 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on *requirements* for system architectural *design*. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for participating in system architectural *design*.
5.4.1 System-wide architectural design decisions
5.4.2 System architectural *design*

5.5 Software requirements analysis. This paragraph **shall** describe the approach to be followed for software requirements analysis. See Section 5.5 in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on software requirements analysis.

5.6 Software architecture and design. See Section 5.6 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on software *architecture* and *design*. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for software *design*.
5.6.1 Overall software *architecture*
5.6.2 Software item *architecture*
5.6.3 Software item detailed *design*
5.6.3.1 Software unit detailed *design*
5.6.3.2 Software interface *design*
5.6.3.3 Database *design*, as *applicable*
5.6.3.4 User interface *design*, as *applicable*
5.6.3.5 Other applicable software *design* (e.g., model-based software, as *applicable)*

5.7 Software implementation and unit testing. See Section 5.7 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on software implementation and unit *testing*. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for software implementation and unit *testing*.
5.7.1 Implementing *software*
5.7.2 Preparing for unit *testing*
5.7.3 Performing unit *testing*
5.7.4 Analyzing and recording unit testing results
5.7.5 Unit *regression testing*
5.7.6 Revising and retesting units

5.8 Unit integration and testing. See Section 5.8 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on software unit integration and *testing*.

This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for unit integration and *testing*.

5.8.1 Testing on the *target computer system*
5.8.2 Preparing for unit integration and *testing*
5.8.3 Performing unit integration and *testing*
5.8.4 Analyzing and recording unit integration and *test* results
5.8.5 Unit integration *regression testing*
5.8.6 Revising and retesting unit integration

5.9 Software item qualification testing. See Section 5.9 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on *software item qualification testing*. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for *software item qualification testing*.

5.9.1 Independence in *software item qualification testing*
5.9.2 Testing on the *target computer system*
5.9.3 Preparing for *software item qualification testing*
5.9.4 Dry run of *software item qualification testing*
5.9.5 Performing *software item qualification testing*
5.9.6 Analyzing and recording *software item qualification test* results
5.9.7 Software item qualification *regression testing*
5.9.8 Revising and retesting *software items*

5.10 Software-hardware item integration and testing. See Section 5.10 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on *software-hardware item* integration and *testing*. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for participating in *software-hardware item* integration and *testing*.

5.10.1 Testing on the *target computer system*
5.10.2 Preparing for *software-hardware item* integration and *testing*
5.10.3 Performing *software-hardware item* integration and *testing*
5.10.4 Analyzing and recording *software-hardware item* integration and *test* results
5.10.5 Software-hardware item integration *regression testing*
5.10.6 Revising and retesting *software-hardware item* integration

5.11 System qualification testing. See Section 5.11 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on system *qualification testing*. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for participating in system *qualification testing*.

5.11.1 Independence in system *qualification testing*
5.11.2 Testing on the *target computer system(s)*
5.11.3 Preparing for system *qualification testing*
5.11.4 Dry run of system *qualification testing*
5.11.5 Performing system *qualification testing*
5.11.6 Analyzing and recording system *qualification test* results
5.11.7 System qualification *regression testing*
5.11.8 Revising and retesting the *system*

5.12 Preparing for software transition to operations. See Section 5.12 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on preparing for *software transition* to operations. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for preparing for *software transition* to operations.

5.12.1 Preparing the executable *software*
5.12.2 Preparing version descriptions for *user sites*
5.12.3 Preparing user manuals
5.12.3.1 Software user manuals
5.12.3.2 Computer operations manuals
5.12.4 Installation at *user sites*

5.13 Preparing for software transition to maintenance. See Section 5.13 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on preparing for *software transition* to *maintenance*. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for preparing for *software transition* to *maintenance*.

5.13.1 Preparing the executable *software*
5.13.2 Preparing source files
5.13.3 Preparing version descriptions for the *maintenance* site(s)
5.13.4 Preparing the "as built" software *architecture*, *design,* and related information
5.13.5 Updating the *system*/*subsystem design* description
5.13.6 Updating the software *requirements*
5.13.7 Updating the *system requirements*
5.13.8 Preparing *maintenance* manuals
5.13.8.1 Computer programming manuals
5.13.8.2 *Firmware* support manuals
5.13.9 *Transition* to the designated *maintenance* site

5.14 Software configuration management. See Section 5.14 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on software configuration management. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for software configuration management.

5.14.1 Configuration identification
5.14.2 Configuration control
5.14.3 Configuration status accounting
5.14.4 Configuration audits
5.14.5 Packaging, storage, handling, and delivery
5.14.6 *Baselines*

5.15 Software peer reviews and product evaluations. See Section 5.15 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on software peer reviews and product *evaluations*. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for software peer reviews and product *evaluations*.

5.15.1 Software peer reviews
5.15.1.1 Plan for software peer reviews
5.15.1.2 Prepare for an individual peer review
5.15.1.3 Conduct peer reviews
5.15.1.4 Analyze and report peer review data
5.15.2 Product *evaluations*
5.15.2.1 In-process and final product *evaluations*
5.15.2.2 Product *evaluation* records
5.15.2.3 Independence in product *evaluations*

5.16 Software quality assurance. See Section 5.16 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on software quality assurance. This

paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for software quality assurance.

5.16.1 Software quality assurance *evaluations*
5.16.2 Software quality assurance records
5.16.3 Independence in software quality assurance
5.16.4 Software quality assurance noncompliance issues

5.17 Corrective action. See Section 5.17 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on corrective action. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for corrective action.

5.17.1 *Discrepancy and change reports (DCRs)*
These *DCRs* **shall** include the items to be recorded specified in Appendix C, Table C.2-5 of (SDSMCS).
5.17.2 Corrective action system

5.18 Joint technical and management reviews. See Section 5.18 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on joint technical and management reviews. See Appendix E, Joint Technical and Management Reviews for additional *requirements* for joint technical and management reviews. This paragraph **shall** be divided into the following subparagraphs to describe the approach to be followed for joint technical and management reviews.

5.18.1 Joint technical reviews
5.18.2 Joint management reviews

5.19 Software risk management. This paragraph **shall** describe the approach for performing *risk* management. See Section 5.19 in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on software *risk* management.

5.20 Software measurement. This paragraph **shall** briefly summarize the approach to be used for software measurement throughout the system development lifecycle. This paragraph **shall** also itemize the specific software measurements to be collected, analyzed, interpreted, applied, and reported. In addition, this paragraph **shall** summarize the importance of each specific measurement used for decision making, corrective actions, and reporting to the *acquirer*. See Section 5.20 and its subparagraphs in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on software measurement. When a separate software measurement plan (SMP) is not required on *contract*, this paragraph **shall** include the content described in the SMP template provided in Appendix H.4. When a separate SMP is required on *contract*, this paragraph **shall** include a reference to the SMP.

5.20.1 Software measurement planning
5.20.2 Software measurement reporting
5.20.3 Software measurement working group (SMWG)

5.21 Security and privacy. This paragraph **shall** describe the approach for meeting the *security* and privacy *requirements*. See Section 5.21 in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on *security* and privacy.

5.22 Software team member management. This paragraph **shall** list all software *developers* at any level (e.g., *prime contractor*, *software team members*). This paragraph **shall** identify all *software,* including custom, *COTS*, modified, and reused, developed by foreign contractors at any level (e.g.,

prime contractor, *software team members*) that will be delivered to the *acquirer*. This paragraph **shall** identify the foreign contractor's company name and foreign location(s). A "foreign contractor" means any foreign corporation, business association, partnership, trust, society or any other entity or group that is not incorporated or organized to do business in the United States, as well as international organizations, foreign Governments, and any agency or subdivision of foreign Governments (e.g., diplomatic missions). This paragraph **shall** describe the approach for performing *software team member* management. This paragraph **shall** specify the mechanisms to be used to ensure that all *contractual requirements,* and all changes to *contractual requirements,* are flowed down to all levels of *software team members*. See Section 5.22 in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on *software team member* management.

5.23 Interface with software independent verification and validation (IV&V) agents. This paragraph **shall** describe the approach for interfacing with the software *IV&V* agents. See Section 5.23 in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on interfacing with software independent verification and validation agents.

5.24 Coordination with associate developers. This paragraph **shall** describe the approach for performing the coordination with *associate developers*, working groups, and *interface* groups. See Section 5.24 in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on coordination with *associate developers*.

5.25 Improvement of project processes. This paragraph **shall** describe the approach for performing the improvement of project *processes*. See Section 5.25 in the body of (SDSMCS) for the activities and topics to be addressed in this paragraph on improvement of project *processes*.

6. Schedules and activity network. This section **shall** be divided into the following paragraphs:

6.1 Schedule. This paragraph **shall** present schedule(s) identifying the activities and showing initiation of each activity, availability of draft and final deliverables, other milestones, and completion of each activity. This paragraph **shall** provide the detailed schedule activities for each *software item,* and other *software*, for each build, and for the entire *software development* lifecycle. See paragraph 7.2.1.4 below for inclusion of the rationale for the software cost and schedule estimation, including software cost and schedule estimation techniques, the input to those techniques (e.g., software size and *software* cost driver parameters and scale factors), and any assumptions made.

6.2 Activity network. An activity network depicting sequential relationships and dependencies among activities and identifying those activities that impose the greatest time restrictions on the project.

7. Project organization and resources. This section **shall** be divided into the following paragraphs to describe the project organization and resources.

7.1 Project organization. This paragraph **shall** be divided into the following subparagraphs to describe the organizational structure to be used on the project, including the organizations involved, their relationships to one another, and the authority and responsibility of each organization for carrying out required activities.
Note: *COTS software suppliers* are not included in this paragraph and its subparagraphs.

7.1.1 Software team members. This paragraph **shall** identify each geographic site of each *software team member* organization that is performing the project-related effort for any software-related activities. (See Section 3.1 of the body of (SDSMCS) for the definition of *software team member*.)

For each *software team member* organization site this paragraph **shall** include all of the following information:

a. Organization site name (e.g., XYZ Co. Div ABA, City, State);
b. Parent organization name (e.g., company);
c. Internal organization name, i.e., name of division or other level (e.g., ground software development);
d. Organization site location, i.e., city, state, and country;
e. Software-related activities that the *software team member* is expected to be performing at this site; and
f. The internal structure of each *software team member*, showing all software-related entities (e.g., software development groups, test groups, software process organizations, software quality assurance, software configuration management) and how they relate to other project and organizational entities (e.g., program management, systems engineering, system integration and test, hardware engineering, quality assurance, configuration management).
   Note: References to supplied organization charts could provide this information for item f.

7.1.2 Full set of project software. This paragraph **shall** identify the full set of *software items* and other *software* for all *categories of software* for this project. This paragraph **shall** include for each *software item* and other *software*:

a. Name of the *software item* or other *software*;
b. *System, subsystem,* and any other *components* to which the *software* belongs;
c. *Category of software*;
d. For each *software team member* responsible for all or part of the *software item* or other *software*, identify the:
   (1) Responsible *software team member*;
   (2) Organization site name, i.e., same as in 7.1.1.a;
   (3) Part(s) of the *software item* or other *software* for which the *software team member* is responsible;
   (4) Source of *software,* i.e., new, reused as is, modified reuse, *COTS*; and
   (5) If the *software* is of mixed source, then list the percentages of each type of source.

7.1.3 Software team receiver-giver relationships. This paragraph **shall** show the *contractual* and intracorporation receiver-giver relationships among the *software team members,* including the *prime contractor*. An internal *software team member* receiver is the *software team member* requiring and receiving a *software item,* or other *software,* from one of the other *software team member*s. An internal *software team member* giver is the *software team member* supplying or giving the required *software item* or other *software* to the *software team member* that required the *product*. This paragraph **shall** be organized by internal *software team member* receiver with the *prime contractor* relationships first. If a single *software team member* has multiple sites performing software-related efforts on this project, then each organization site **shall** be treated separately. For each internal receiver-giver pair, this paragraph **shall** identify each *software item,* and other *software,* produced by the internal giver for the internal receiver. This paragraph **shall** include for each receiver-giver *software team member* relationship:

a. Internal *software team member* receiver organization site name,
b. Internal *software team member* giver organization site name, and
c. List of name(s) of each *software item* and other *software* to be produced by the giver for the receiver.

7.2 Project resources. This paragraph **shall** be divided into the following subparagraphs to describe the resources to be applied to the project.

7.2.1 Personnel resources. This paragraph **shall** provide the following items for the entire *software development* lifecycle and for each *software item,* and other *software*:

- 7.2.1.1 Staff hours by software item. The estimated staff-loading for the project i.e., number of total personnel hours by month throughout the system development lifecycle, broken out as follows:
  - a. For each *software team member:*
    - (1) For each *software item* and other *software*,
    - (2) For each other piece of *software*,
    - (3) For each *build*, and
    - (4) For the entire *software development* lifecycle; and
  - b. For all *software team members* for the entire *software development* effort.
- 7.2.1.2 Staff hours by responsibility. The breakdown of the staff-loading for the project, i.e., number of total personnel hours by month throughout the system development life cycle, broken out by responsibility (for example, management, *software engineering*, *software testing*, *software* configuration management, product *evaluation*, *software* quality assurance):
  - a. For each *software team member:*
    - (1) For each *software item*,
    - (2) For each other piece of *software,*
    - (3) For each *build*, and
    - (4) For the entire *software development* lifecycle; and
  - b. For all *software team members* for the entire *software development* effort.
- 7.2.1.3 Number of personnel by skill level. For each *software team member*, a breakdown of the number of personnel by skill level of those personnel performing each responsibility used in paragraph 7.2.1.2:
  - a. For each *software team member:*
    - (1) For each *software item*,
    - (2) For each other piece of *software,*
    - (3) For each *build*, and
    - (4) For the entire *software development* lifecycle; and
  - b. For all *software team members* for the entire *software development* effort.
- 7.2.1.4 Rationale. The rationale for the schedule estimates in paragraph 6.1 and the effort and head count estimates in section 7.2, including *software* cost and schedule estimation techniques, the input to those techniques (e.g., *software* size and *software* cost driver parameters and scale factors), and any assumptions made.
- 7.2.1.5 Training. Description of the training required for each *software team member* organization site. Also a description of the training required for each new staff member.

7.2.2 Overview of developer facilities. For each organization site, this paragraph **shall** list the development and test facilities, secure areas, and other site features to be used, as *applicable* to the *software development*, including which work will be performed at each facility, area, or other site feature. This paragraph **shall** include a schedule detailing when these items will be needed, developed or acquired, and validated.

7.2.3 Acquirer-furnished equipment and information. This paragraph **shall** list *acquirer*-furnished equipment*, software*, services, *documentation*, data, and facilities, as *applicable*, required for the

software development effort. A schedule detailing when these items will be needed **shall** also be included.

7.2.4 Other required resources, This paragraph **shall** list other required resources, including a plan for obtaining the resources, dates needed, and availability of each resource item.

8. Notes. This section **shall** contain any general information that aids in understanding this *document* (e.g., background information, glossary, rationale). This section **shall** be divided into the following paragraphs.

8.1 Abbreviations and acronyms. This paragraph **shall** include an alphabetical listing of all acronyms, abbreviations, and their meanings as used in this *document*.

8.2 Glossary. This paragraph **shall** include a list of any terms and their definitions needed to understand this *document*. Terms often used differently between organizations (e.g., acquisition phase names, *build*, block, development phase names, effectivity, evolution, increment, and iteration) **shall** be defined to avoid confusion. If the terms used are exactly as defined in the Software Development Standard (SDSMCS), they need not be redefined here.

8.3 General information. This paragraph **shall** contain any other general information that aids in understanding this *document* (e.g., background information, rationale).

A. Appendices. Appendices may be used to provide information published separately for convenience in *document maintenance* (e.g., charts, classified data). As *applicable*, each appendix **shall** be referenced in the main body of the *document* where the data would normally have been provided. Appendices may be bound as separate *documents* for ease in handling. Appendices **shall** be lettered alphabetically (Appendix A, B, etc.).

END of SDP Template

H.2 Software Architecture Description (SAD) Template

This appendix is a MANDATORY part of the (SDSMCS). It provides the content *requirements* for the Software Architecture Description (SAD).

1. If the section numbering used below is not used, the *developer* **shall** provide an appendix in the SAD with a traceability matrix mapping from the section numbers and titles below to the section numbers and titles used in the *developer's* SAD.
2. If there is such a traceability mapping appendix, it **shall** be referenced in Section 1.3.

Purpose: The Software Architecture Description (SAD) documents the software *architecture*, including the approach, important design decisions, rationale, and tradeoffs. It provides diagrams and text to document the various architectural views from different perspectives and serves as the basis for the detailed *design*.

References

(SDSMCS) Adams, R. J., S. Eslinger, K. L. Owens, J. M. Tagami, and M. A. Zambrana, *Software Development Standard for Mission Critical Systems (SDSMCS)*, Aerospace Report No. TR-RS-2015-00012, March 17, 2014, The Aerospace Corporation. This is the same as SMC Standard SMC-S-012, *Software Development Standard*.

Content Requirements

This template contains the required content of the SAD. See Section 3 of the Software Development Standard for Mission Critical Systems (SDSMCS) for definitions of all italicized words or phrases.

1. Scope. This section **shall** be divided into the following paragraphs.

1.1 Identification. This paragraph **shall** contain a full identification of the *system* and the *software* to which this *document* applies, including, as *applicable*, identification number(s), title(s), abbreviation(s), version number(s), and release number(s).

1.2 System overview. This paragraph **shall** briefly state the purpose of the *system* and the *software* to which this *document* applies. It **shall**: a) describe the general nature of the *system* and *software*; b) summarize the history of system development, operation, and maintenance; c) identify the project sponsor, *acquirer*, *user*, *developer*, and support organizations; and d) identify current and planned operating and *user sites*.

1.3 Document overview. This paragraph **shall** summarize the purpose and contents of this *document*. This paragraph **shall** describe any security or privacy considerations associated with its use.

1.4 Relationship to other documents. This paragraph **shall** describe the relationship, if any, of the SAD to other project *documents*.

2. Referenced documents. This section **shall** list the number, title, revision, and date of all *documents* referenced in this plan. This section **shall** also identify the source for all *documents* not available through normal Government stocking activities.

3. Software architecture plans and processes. This section **shall** be divided into paragraphs as specified below to describe the plans and processes for developing the software *architecture*.

3.1 Software architecture plans. The paragraph **shall** provide an overview of the software *architecture* plans and activities. This paragraph **shall** identify the *software team members* responsible for developing and evaluating the software *architecture*, including their responsibilities. This paragraph **shall** also identify other stakeholders in the software *architecture*, including their roles.

3.2 Software architecture processes and tools. This paragraph **shall** describe how the software *architecture* has been developed in accordance with the detailed methods, techniques and tools specified in the Software Development Plan (SDP). This paragraph **shall** identify the architecture modeling tools and other tools and techniques (e.g., Unified Modeling Language) used to develop and maintain the software *architecture*, including representing, *documenting,* and analyzing the software *architecture*; performing consistency analyses; and mapping *requirements* to architectural *components*. This paragraph **shall** describe how the software *architecture* evolves from high-level architectural *components* and *interfaces* to lower level *components* and *interfaces* and how the lower-level *components* and *interfaces* will transition to the software *design*. This paragraph **shall** identify the scope of the software *architecture*; that is, what design decisions are and are not considered part of the software *architecture*.

4. Software architecture requirements and approach. This section **shall** be divided into paragraphs as specified below to describe the software architecture *requirements* and approach.

4.1 Software architecture critical and driving requirements. This paragraph **shall** identify: a) all critical *requirements* specified in the SDP (See (SDSMCS) Section 4.2.5); b) all other *nonfunctional requirements* that are drivers of software *architecture* decisions; and c) all *functional requirements* that are drivers of software *architecture* decisions. This paragraph **shall** contain a prioritized list of these critical and driving *requirements* according to their importance in software architecture decisions.
Note 1: *Nonfunctional requirements* are also called "quality attributes." See definition of "*nonfunctional requirement*" in (SDSMCS), Section 3, Terms.
Note 2: Providing the critical and driving requirements identifiers n lieu of the actual requirement statements is acceptable.

4.2 Software architecture approach. This paragraph **shall** discuss the selected architectural approach, as well as alternatives that were considered to address the critical and driving *requirements* specified in paragraph 4.1 above. This paragraph **shall** describe the analyses and trade studies that were performed to evaluate the architectural alternatives for their ability to satisfy the critical and driving *requirements*. This paragraph **shall** describe how the results of these analyses and trade studies support the selected software architecture approach.

4.3 Software architecture evaluations. This paragraph **shall** describe all *evaluations* performed, or to be performed, of the selected software *architecture*, either by a *developer* team, an *acquirer* team, or a combined team. For *evaluations* that have been performed, this paragraph **shall** describe the results of these *evaluations*, with references to analysis details, especially with respect to the ability of the selected software *architecture* to meet the critical and driving *requirements* specified in paragraph 4.1 above. This paragraph **shall** describe any changes to software architecture decisions as a result of these *evaluations*.

4.4 Software architecture risks. This paragraph **shall** identify the software *risks* for the selected software *architecture*. This paragraph **shall** describe any analyses performed to evaluate these *risks*, the results of those analyses, with references to analysis details, and any mitigation actions taken or being undertaken for the *risks*.

5. Overall software architecture description. This paragraph **shall** provide the overall software *architecture* for all *software* on the *contract*, including all *categories of software* covered by the *contract* (see Section 1.2.5.6 of the (SDSMCS)). The overall software architecture description provided in this section **shall** be at the level of granularity that crosses *software items*. The following topics **shall** be addressed to describe the overall software *architecture*. The following topics *may* be discussed in any order chosen by the *developer*.
   a. A high-level description and diagrams of the software *architecture*.
   b. A description of how the software *architecture* integrates into the *system* and *subsystem architectures* and addresses the system operations concept and the primary threads that the *system* supports.
   c. A description of the relationship between the software *architecture* and any external *systems*.
   d. A description of how the software *architecture* addresses the critical and driving *requirements* (identified in paragraph 4.1 above) and their impact on the *architecture*.
   e. A description of the architecture style(s), applied design principles, key software architectural patterns, and constraints.
   f. A description, expressed in a set of use cases, or equivalent, of how the *software* will interact with the *users* and with other *systems* and *subsystems* to meet system and software *requirements*, including use cases, or equivalent, for *nominal* and *off-nominal* (e.g., alternative, error, and fault) scenarios.
   g. Descriptions of the following software architectural views, including both diagrams and detailed textual descriptions. All diagrams **shall** be accompanied by descriptions of the functionality and behavior provided by the *components*. This paragraph **shall** describe how the views address the concerns of the relevant stakeholders. This paragraph **shall** provide the criteria used to determine consistency among the architectural views. If additional views are used by the *developer* to describe the software *architecture*, those views **shall** be included here. The views **shall** include the following information, along with the rationale and the alternatives that were explored:
      (1) Descriptions, including diagrams and text, of logical architecture *components*, connectors, and *interfaces,* both internal and external. This paragraph **shall** include the functionality of each *component* and connector and the interactions and dependency relationships among *components*. This paragraph **shall** include the conceptual and logical data schema for key data structures, along with a description of the relationship between these data structures and the software *architecture* and algorithms;
      (2) Descriptions, including diagrams and text, of the architecture component behaviors, interactions, and collaborations required by each use case, or equivalent, using techniques such as sequence diagrams, activity diagrams, and state machine diagrams. This paragraph **shall** also include descriptions of states and modes and transitions among them, as *applicable*. Descriptions of important internal *component* behaviors **shall** also be included;
      (3) Descriptions, including diagrams and text, of the physical organization of the *software*. This paragraph **shall** include the target processors, both physical and virtual, on which *components* will execute, and their interconnections. This paragraph **shall** describe how software *components*, connectors, and other elements will be allocated to the target processors. This paragraph **shall** describe how and where *system* data are stored and accessed. This paragraph **shall** identify important software-to-hardware *interfaces*. This paragraph **shall** identify any special purpose hardware and any special target processor characteristics that have software impacts; and
      (4) Identification and descriptions of the *software items* and other *software* in the overall software *architecture*, including all *categories of software*. This paragraph **shall** also

include the mapping of the *software items* and other *software* to the software architectural *components*.

h. Identification of *commercial off-the-shelf (COTS) software products* that will be used to implement part or all of any software architecture *components*, including:
   (1) Relationship of each *COTS software product* to the software architecture *component(s)* it implements, what part(s) of the *component(s) are* implemented by each *COTS software product*, and whether the full capabilities of the *COTS software products* are used;
   (2) Discussion of alternative *products* evaluated, the *evaluation* criteria used, and how each *product* met the *evaluation* criteria;
   (3) Discussion of the data rights, including licensing, associated with each *COTS software product*; and
   (4) Discussion of how any mismatches between the *COTS software product* and the *architecture* will be resolved.

i. Identification of *reusable software products,* i.e., noncommercial off-the-shelf, that will be used to implement part or all of any software *architecture* component, including:
   (1) Relationship of each *reusable software product* to the software architecture *component(s)* it implements, what part(s) of the *component(s)* are implemented by each *reusable software product*, and whether the full capabilities of the *reusable software products* are used;
   (2) For each *reusable software product*, a description of what is being reused (e.g., *requirements*, *design*, algorithms, code, *test cases*), and the magnitude of expected modifications to the *reusable software component*;
   (3) Discussion of alternative *products* evaluated, the *evaluation* criteria used, and how each product met the *evaluation* criteria;
   (4) Discussion of the data rights associated with each *reusable software product*; and
   (5) Discussion of how any mismatches between the *reusable software product* and the *architecture* will be resolved.

j. Description of how and where the *architecture* supports Modular Open Software Approach (MOSA) principles.

k. Description of how and where the *architecture* supports net-centricity principles, if *applicable*.

l. Description of how and where the software *architecture* supports *information assurance* and *cyber-security requirements*, including *security* assurance assessment and certification and accreditation activities). Examples of supporting descriptions include:
   (1) Principles that guide the security *design* of the *software* within the *system* (e.g., use of defense-in-depth, modularity and isolation of security-critical functionality, nonbypassability of security function chokepoints);
   (2) Identification of system security policies (e.g., identification and authentication, access control, confidentiality, integrity, data provenance, nonrepudiation, accountability); and how they will be enforced by the software architecture;
   (3) Identification of policy decision points and policy enforcement points within the software *architecture*, including the technology and product choices for each;
   (4) Identification of security domains, security modes (e.g., system high, dedicated), and cross-domain solutions, including the types of data that they must handle;
   (5) Detailed descriptions for aspects of the system security *design* that require a high level of security assurance (e.g., key management design supporting National Security Agency Type 1 encryption); and
   (6) Detailed descriptions for aspects of the software architectural *design* that help support cyber resilience, that is, the ability of a *system* to operate in the face of persistent cyber attacks and still support mission success (e.g., redundancy of *components*, request

throttling, virtualization or partitioning of resources, deployment of *security* application tools).

m. Description of how and where the software *architecture* implements the supportability of the *system*, that is, the repair, scheduled *maintenance*, and preventive *maintenance* required to retain the *system* in, or restore the *system* to, a state in which it can perform its required functions, including the ability of personnel to install, configure, and monitor computer products, identify exceptions or faults, debug or isolate faults to root-cause analysis, and provide hardware or *software maintenance* in pursuit of solving a problem and restoring the *product* into service.

n. Description of how and where the software *architecture* supports system *reliability*, *maintainability, availability* (*RMA*), and *safety*, including the architectural decisions made to support *RMA* and *safety*, the fault management *architecture*, use of other architectural features to address *RMA* and *safety* (e.g., redundancy, automated failover, fault tolerance), and uniform exception handling and recovery methods.

o. If *applicable*, a description of how and where the software *architecture* supports the human systems interface to account for human capabilities and limitations in the operations, *maintenance*, and support of the *system*. This description **shall** include architecture decisions concerning user interface screen design and user interaction mechanisms for user input and output. This description **shall** include, if *applicable*:
   (1) How the software *architecture* isolates the user interface from the application logic;
   (2) Principal design decisions made to ensure *usability* by the human operator;
   (3) Principal design decisions made to ensure that the user interface is internally consistent across all *software* in the overall software *architecture*;
   (4) Principal design decisions made to ensure that the user interface is consistent with widely used application user interfaces;
   (5) Principal design decisions made to ensure the quantity and frequency of data presented to the operator, including alarms, warnings, and error messages, are able to be assimilated and responded to by the operator within the needed response time; and
   (6) Applicable human systems interface standards (e.g., graphical user interface (GUI) standards) and how those standards are used within the *architecture*.

p. Description of how the software *architecture* supports the selected *software development lifecycle model(s)* and the integration of *software* and hardware in each software *build* and system increment.

q. Discussion of other principal and *architecture*-wide design decisions that are not covered by the above items. Examples include the following:
   (1) *Applicable* standards (e.g., *interface* standards, open system standards) and how those standards are used within the *architecture*;
   (2) Application programming interfaces (APIs) to be used;
   (3) Algorithms to be used;
   (4) Communications mechanisms (e.g., publish and subscribe message passing, calling sequences, shared memory, sockets) to be used between software entities and under which circumstances each mechanism is to be used; and
   (5) Definitions of uniform data storage and access methods.

r. Requirements traceability. This paragraph **shall** provide *bidirectional traceability*:
   (1) Between the software *architecture components* and the software *requirements* and software interface *requirements*; and
   (2) Between the use cases, or equivalent, and the software *requirements* and software interface *requirements*.

6. Software item architecture description. This paragraph **shall** provide the software *architecture* for the individual *software items* on the *contract*, including all *categories of software* covered by the *contract* (see Section 1.2.5.7 of the (SDSMCS)). This paragraph **shall** be divided into

subparagraphs to describe the software *architecture* of each *software item*. The paragraphs containing an ".x" in their numbers and an "x" in their names **shall** be repeated for each *software item* "x."

6.x Software architecture description for software item x <Insert Name>. This paragraph **shall** describe the software *architecture* for *software item* x. This software item *architecture* description for *software item* x may be included in this paragraph or in a separate appendix that is referenced from this paragraph. The software item *architecture* description provided in this paragraph **shall** be at the level of granularity that includes all the *software units* in the *software item*. The following topics **shall** be addressed to describe the software item *architecture*. (The following topics *may* be discussed in any order chosen by the *developer*.)

a. A high-level description and diagrams of the software item *architecture*. This paragraph **shall** also include a description of how the software item *architecture* evolves from and is consistent with the overall software *architecture* described in paragraph 5 above.
b. A description of how the software item *architecture* integrates into the *system* and *subsystem architectures* and how the software item *architecture* addresses the *system* operations concept and the primary system threads that the *software item* supports.
c. A description of the relationship between the software item *architecture* and any external *systems*.
d. A description of how the software item *architecture* addresses the critical and driving *requirements,* i.e., identified in Paragraph 4.1 above, allocated to *software item* x and their impact on the software item *architecture*.
e. A description of the architecture style(s), applied design principles, key software architectural patterns, and constraints that apply to the software item *architecture*.
f. A description, expressed in a set of use cases, or equivalent, of how the *software item* will interact with the *users* and with other *systems* and *subsystems* to meet *system* and *software requirements*, including use cases, or equivalent, for *nominal* and *off-nominal* (e.g., alternative, error, and fault) scenarios.
g. Descriptions of the following software architectural views, including both diagrams and detailed textual descriptions. All diagrams **shall** be accompanied by descriptions of the functionality and behavior provided by the software item architecture *components*. This paragraph **shall** describe how the views address the concerns of the relevant stakeholders. This paragraph **shall** provide the criteria used to determine consistency among the software item architectural views. If additional views are used by the *developer* to describe the software item *architecture*, those views **shall** be included here. The views **shall** include the following information for the software item *architecture*, along with the rationale and the alternatives that were explored:
   (1) Descriptions, including diagrams and text, of logical software item architecture *components*, connectors, and *interfaces,* both internal and external. This paragraph **shall** include the functionality of each *component* and connector and the interactions and dependency relationships among *components*. This paragraph **shall** include the conceptual and logical data schema for key data structures, along with a description of the relationship between these data structures and the software item *architecture* and algorithms;
   (2) Descriptions, including diagrams and text, of the software item *architecture component* behaviors, interactions, and collaborations required by each use case, or equivalent, using techniques such as sequence diagrams, activity diagrams, and state machine diagrams. This paragraph **shall** also include descriptions of states and modes and transitions among them, as *applicable*. Descriptions of important internal *component* behaviors **shall** also be included;
   (3) Descriptions, including diagrams and text, of the physical organization of the *software item*. This paragraph **shall** include the physical and virtual target processors on which

software item architecture *components* will execute and their interconnections. This paragraph **shall** describe how software item *architecture components*, connectors, and other elements will be allocated to the target processors. This paragraph **shall** describe how and where *system* data created or used by the *software item* are stored and accessed. This paragraph **shall** identify important *software*-to-hardware *interfaces*. This paragraph **shall** identify any special-purpose hardware and any special target processor characteristics that have impacts on the *software item*; and

(4) Identification and descriptions of the *software units* in the software item *architecture*. This paragraph **shall** also include the mapping between the *software units* and the software item architectural *components*.

h. Identification of *commercial off-the-shelf (COTS) software products* that will be used to implement part or all of any software item architecture *components*, including:
   (1) Relationship of each *COTS software product* to the software item architecture *component(s)* it implements, what part(s) of the *component(s)* are implemented by each *COTS software product*, and whether the full capabilities of the *COTS software products* are used;
   (2) Discussion of alternative *products* evaluated, the *evaluation* criteria used, and how each *product* met the *evaluation* criteria;
   (3) Discussion of the data rights, including licensing, associated with each *COTS software product*; and
   (4) Discussion of how any mismatches between the *COTS* software *product* and the software item *architecture* will be resolved.

i. Identification of *reusable software products,* i.e., noncommercial off-the-shelf, that will be used to implement part or all of any software item architecture *component*, including:
   (1) Relationship of each *reusable software product* to the software item architecture *component(s)* it implements, what part(s) of the *component(s)* are implemented by each *reusable software product*, and whether the full capabilities of the *reusable software products* are used;
   (2) For each *reusable software product*, a description of what is being reused (e.g., *requirements*, *design*, algorithms, code, *test cases*), and the magnitude of expected modifications to the *reusable software component*;
   (3) Discussion of alternative *products* evaluated, the *evaluation* criteria used, and how each product met the *evaluation* criteria;
   (4) Discussion of the data rights associated with each *reusable software product*; and
   (5) Discussion of how any mismatches between the *reusable software product* and the software item *architecture* will be resolved.

j. Description of how and where the software item *architecture* supports Modular Open Software Approach (MOSA) principles.

k. Description of how and where the software item *architecture* supports net-centricity principles, if *applicable*.

l. Description of how and where the software item *architecture* supports *information assurance* and *cyber-security requirements*, including *security* assurance assessment and certification and accreditation activities). Examples of supporting descriptions include:
   (1) Principles that guide the security design of the *software item* within the *system* (e.g., use of defense-in-depth, modularity and isolation of security-critical functionality, nonbypassability of security function chokepoints);
   (2) Identification of system security policies (e.g., identification and authentication, access control, confidentiality, *integrity*, data provenance, nonrepudiation, accountability) and how they will be enforced by the software item *architecture*;
   (3) Identification of policy decision points and policy enforcement points within the software item *architecture*, including the technology and product choices for each;

(4) Identification of security domains, security modes (e.g., system high, dedicated), and cross-domain solutions, including the types of data that they must handle;
(5) Detailed descriptions for aspects of the system security *design* that require a high level of security assurance (e.g., key management design supporting National Security Agency Type 1 encryption); and
(6) Detailed descriptions for aspects of the software item architectural *design* that help support cyber resilience, that is, the ability of a *system* to operate in the face of persistent cyber attacks and still support mission success (e.g., redundancy of *components*, request throttling, virtualization or partitioning of resources, deployment of *security* application tools).

m. Description of how and where the software item *architecture* implements the supportability of the *system*, that is, the repair, scheduled *maintenance*, and preventive *maintenance* required to retain the *system* in, or restore the *system* to, a state in which it can perform its required functions, including the ability of personnel to install, configure, and monitor computer products, identify exceptions or faults, debug or isolate faults to root-cause analysis, and provide hardware or *software maintenance* in pursuit of solving a problem and restoring the *product* into service.

n. Description of how and where the software item *architecture* supports system *reliability*, *maintainability*, and *availability* (*RMA*), and *safety*, including the software item architectural decisions made to support *RMA* and *safety*, the fault management *architecture*, use of other architectural features to address *RMA* and *safety* (e.g., redundancy, automated failover, fault tolerance), and uniform exception handling and recovery methods.

o. If *applicable*, a description of how and where the software item *architecture* supports the human systems interface to account for human capabilities and limitations in the operations, *maintenance*, and support of the *system*. This description shall include software item architecture decisions concerning user interface screen design and user interaction mechanisms for user input and output. This description **shall** include, if *applicable*:
(1) How the software item *architecture* isolates the user interface from the application logic;
(2) Principal software item design decisions made to ensure *usability* by the human operator;
(3) Principal software item design decisions made to ensure that the user interface of the *software item* is internally consistent across the software item *architecture*;
(4) Principal software item design decisions made to ensure that the user interface of the *software item* is consistent with widely used application user interfaces;
(5) Principal software item design decisions made to ensure the quantity and frequency of data presented to the operator, including alarms, warnings, and error messages, is able to be assimilated and responded to by the operator within the needed response time; and
(6) Applicable human systems interface standards (e.g., graphical user interface (GUI) standards) and how those standards are used within the software item *architecture*.

p. Description of how the software item *architecture* supports the selected *software development lifecycle model(s)* and the integration of *software* and hardware in each software *build* and system increment.

q. Discussion of other principal and software item *architecture*-wide design decisions that are not covered by the above items. Examples include the following:
(1) *Applicable* standards (e.g., *interface* standards, open system standards) and how those standards are used within the software item *architecture*;
(2) Application program interfaces (APIs) to be used within the *software item*;
(3) Algorithms to be used within the *software item*;
(4) Communications mechanisms (e.g., publish and subscribe message passing, calling sequences, shared memory, sockets) to be used between software entities within the *software item* and under which circumstances each mechanism is to be used; and
(5) Definitions of uniform data storage and access methods within the *software item*.

(6) Requirements traceability. This paragraph shall provide *bidirectional traceability*:
   (a) Between the software item architecture *components* and the software item *requirements* and software item interface *requirements*, and
   (b) Between the use cases, or equivalent, and the software item *requirements* and software item interface *requirements*.

7. Notes. This section **shall** contain any general information that aids in understanding this *document* (e.g., background information, glossary, rationale). This section **shall** be divided into the following paragraphs.

7.1 Abbreviations and acronyms. This paragraph **shall** include an alphabetical listing of all acronyms, abbreviations, and their meanings as used in this *document*.

7.2 Glossary. This paragraph **shall** include a list of any terms and their definitions needed to understand this *document*. Terms often used differently between organizations (e.g., acquisition phase names, *build*, block, development phase names, effectivity, evolution, increment, and iteration) **shall** be defined to avoid confusion. If the terms used are exactly as defined in the Software Development Standard (SDSMCS), they need not be redefined here.

7.3 General information. This paragraph **shall** contain any other general information that aids in understanding this *document* (e.g., background information, rationale).

A. Appendices. Appendices may be used to provide information published separately for convenience in document maintenance (e.g., charts, classified data). As *applicable*, each appendix **shall** be referenced in the main body of the *document* where the data would normally have been provided. Appendices may be bound as separate *documents* for ease in handling. Appendices **shall** be lettered alphabetically (Appendix A, B, etc.).

END of SAD Template

H.3 Software Master Build Plan (SMBP) Template

This appendix is a MANDATORY part of the (SDSMCS). It provides the content *requirements* for the SMBP.

1. If the section numbering used below is not used, the *developer* **shall** provide an appendix in the SMBP with a traceability matrix mapping from the section numbers and titles below to the section numbers and titles used in the developer SMBP.
2. If there is such a traceability mapping appendix, it **shall** be referenced in section 1.3.

Purpose: The Software Master Build Plan (SMBP) includes plans for integrating and verifying the *software* consistent with the *software development lifecycle model(s)*. (The SMBP is sometimes known as the Master Software Integration and Verification Plan.)

References

(SDSMCS) Adams, R. J., S. Eslinger, K. L. Owens, J. M. Tagami, and M. A. Zambrana, *Software Development Standard for Mission Critical Systems (SDSMCS)*, Aerospace Report No. TR-RS-2015-00012, March 17, 2014, The Aerospace Corporation. This is the same as SMC Standard SMC-S-012, *Software Development Standard*.

Content Requirements

This template contains the required content of the SMBP. The content and level of detail of the SMBP is expected to evolve as more information is available and captured. See Section 3 of the Software Development Standard for Mission-Critical Systems (SDSMCS) for definitions of all italicized words or phrases.

1. Scope. This section **shall** be divided into the following paragraphs.

1.1 Identification. This paragraph **shall** contain a full identification of the *system* and the *software* to which this *document* applies, including, as *applicable*, identification number(s), title(s), abbreviation(s), version number(s), and release number(s).

1.2 System overview. This paragraph **shall** briefly state the purpose of the *system* and the *software* to which this *document* applies. It **shall**: a) describe the general nature of the *system* and *software*; b) summarize the history of system development, operation, and maintenance; c) identify the project sponsor, *acquirer*, *user*, *developer*, and support organizations; and d) identify current and planned operating and *user sites*.

1.3 Document overview. This paragraph **shall** summarize the purpose and contents of this *document*. This paragraph **shall** describe any *security* or privacy considerations associated with its use.

1.4 Relationship to other documents. This paragraph **shall** describe the relationship, if any, of the SMBP to the SDP and other project management plans and project documents.

2. Referenced documents. This section **shall** list the number, title, revision, and date of all *documents* referenced in this plan. This section **shall** also identify the source for all *documents* not available through normal Government stocking activities.

3. Software master build plan. This section **shall** provide the philosophy and rationale for the decisions about the contents and progression of the *builds*. This section **shall** provide multiple

perspectives of the *builds*, including descriptions of which *requirements* are in which *builds*, which *software units* and *software items* are integrated in which *builds*, and the integration levels and *qualification testing* levels of the various *builds*. Build content descriptions **shall** include newly developed *software*, *reusable software*, and the *software* used for *verification*. This paragraph **shall** be divided into the following subparagraphs. The paragraphs containing ".x" in their numbers and "x" in their names **shall** be repeated for each *build* "x."

3.1 Planned builds. This paragraph **shall** provide the philosophy and rationale for determining the *builds*, based upon, e.g., required capability need dates by the *acquirer*, a regular integration schedule (e.g., quarterly or monthly), an achievable build development size determined by number of *requirements*, number of lines of *source code*, size of executable *software*, or some other factor. This paragraph **shall** provide the names of the planned *builds*. This paragraph **shall** provide the names of the planned *builds* in relationship to internal milestone reviews, e.g., build reviews and major reviews, e.g., SAR, PDR, CDR, Test Readiness Reviews (TRRs). This paragraph **shall** provide the driving objectives of each *build*.

3.2 Build requirements contents. This paragraph **shall** provide the philosophy and rationale for determining which *requirements* go into which *builds*. This paragraph **shall** summarize the set of *software requirements* that will be included in each *build*. Note: The SMBP can include *requirements* at higher levels than *software*, e.g., element, segment, *subsystem*, and *system requirements*.

3.2.x Build x <Insert Name> requirements. This paragraph **shall** provide the list of software requirements that will be included in *build* "x." For each *requirement,* the *requirement* identifier, a short *requirement* description, the requirements text, and the verification event, as a minimum, **shall** be included. For each *requirement,* this paragraph **shall** indicate if the *requirement* will only be partially implemented in *build* "x."
Note 1: A table can provide this information.
Note 2: This information may be placed in an appendix referenced from this section.
Note 3: If a *software item* is developed in multiple *builds*, its *requirements* might not be fully implemented and verified until the final *build*. The planning identifies the subset of each *software item's requirements* to be implemented in each *build*.

3.3 Build integration levels. This paragraph **shall** provide the philosophy and rationale for determining which *builds* are promoted to a higher level of integration. This paragraph **shall** provide the hierarchy of integration and integration testing. This paragraph **shall** specify responsibilities for each integration level in the integration hierarchy. This paragraph **shall** summarize which levels of integration will occur for each *build*. This paragraph **shall** summarize which levels of integration testing will occur for each *build*.
Note 1: A table can provide this information.
Note 2: It is beneficial to list the hardware on which the software executes, whether it is COTS hardware or special hardware being developed.

3.3.x Build x <Insert Name> integration levels. This paragraph **shall** provide the list of integration level(s) that will be performed for *build* "x." For example, the *build* will integrate *software units* or *software items*:

a. into part of a *software item*,
b. into a whole *software item*,
c. into multiple *software items*,
d. with the *hardware items* on which they execute,
e. into the *subsystem* level,
f. into the *system* level, or

g. any combination of the integration levels.
Note: A table can provide this information.

3.4 Build contents and integration order. This paragraph **shall** provide the philosophy and rationale for determining which units are integrated in which order. This paragraph **shall** specify the location of each integration activity. This paragraph **shall** summarize the *software items* and *software units*, including *reusable software,* that are allocated to each *build*.

3.4.x. Build x <Insert Name> contents and integration order. For build "x," this paragraph **shall** provide the subparagraphs below.

3.4.x.1 Build x <Insert Name> contents. This paragraph **shall** provide the set of *software items* and *software units* that will be included in *build* "x."
Note 1: A table can provide this information.
Note 2: This information may be placed in an appendix referenced from this section.

3.4.x.2 Build x <Insert Name> integration order. This paragraph **shall** provide the intended order of integrating the units for *build* "x."
Note 1: A table can provide this information.
Note 2: This information may be placed in an appendix referenced from this section.

3.5 Build qualification testing levels. This paragraph **shall** provide the philosophy and rationale for determining which *builds* will undergo which levels of *qualification testing*. This paragraph **shall** specify responsibilities for each *qualification test* level. This paragraph **shall** specify the location of each *qualification test* event. This paragraph **shall** summarize the *qualification testing* level(s) for each *build*.

3.5.x Build x <Insert Name> qualification testing levels. This paragraph **shall** provide the list of *qualification testing* levels that will be performed for *build "x."* For example, the *build* will be *qualification tested* at the following level(s), if any: *software item*, software level (e.g., some or all *software items*), element level, segment level, *subsystem* level, or system level. Note: A table can provide this information. This paragraph **shall** provide the allocation of *requirements* to specific *qualification testing* events. This paragraph **shall** specify responsibilities for each *qualification testing* event. This paragraph **shall** specify the location of each *qualification testing* event for *build* "x."

3.6 Build deliveries. This paragraph **shall** provide the philosophy and rationale for determining: a) which *builds* will be delivered to a higher level for internal integration and testing; b) which *builds* will be delivered to a higher level for internal qualification testing; c) which *builds* will be delivered to the *acquirer* for integrated operational test and *evaluation*; and d) which *builds* will be delivered to the *acquirer* for operations. This paragraph **shall** summarize which *builds* will be delivered for internal integration and test. This paragraph **shall** summarize which *builds* will be delivered for higher levels of internal integration, integration testing, and *qualification testing*. This paragraph **shall** summarize which *builds* will be delivered to the *acquirer* for integrated operational test and *evaluation*. This paragraph **shall** summarize which *builds* will be delivered to the *acquirer* for operations.

3.7 Build schedule. This paragraph **shall** summarize when each build will be started and completed. This paragraph **shall** summarize when each *build* will be delivered for each level of integration. This paragraph **shall** summarize when each *build* will be delivered for each level of *qualification testing*. This paragraph **shall** summarize when each *build* will be delivered to the

acquirer for integrated operational test and operations. This paragraph **shall** summarize when each *build* will be delivered to the *acquirer* for operations.

4. Notes. This section **shall** contain any general information that aids in understanding this *document* (e.g., background information, glossary, rationale). This section **shall** be divided into the following paragraphs.

4.1 Abbreviations and acronyms. This paragraph **shall** include an alphabetical listing of all acronyms, abbreviations, and their meanings as used in this *document*.

4.2 Glossary. This paragraph **shall** include a list of any terms and their definitions needed to understand this *document*. Terms often used differently between organizations (e.g., acquisition phase names, *build*, block, development phase names, effectivity, evolution, increment, and iteration) **shall** be defined to avoid confusion. If the terms used are exactly as defined in the Software Development Standard (SDSMCS), they need not be redefined here.

4.3 General information. This paragraph **shall** contain any other general information that aids in understanding this *document* (e.g., background information, rationale).

A. Appendices. Appendices may be used to provide information published separately for convenience in document maintenance (e.g., charts, classified data). As *applicable*, each appendix **shall** be referenced in the main body of the *document* where the data would normally have been provided. Appendices may be bound as separate *documents* for ease in handling. Appendices **shall** be lettered alphabetically (Appendix A, B, etc.).

END of SMBP Template

H.4 Software Measurement Plan (SMP) Template

This appendix is a MANDATORY part of the (SDSMCS). It provides the content *requirements* for the SMP.

1. If the section numbering used below is not used, the *developer* **shall** provide an appendix in the SMP with a traceability matrix mapping from the section numbers and titles below to the section numbers and titles used in the developer SMP.
2. If there is such a traceability mapping appendix, it **shall** be referenced in Section 1.3.
   Note 1: The information shown below is consistent with the Software Development Standard for Mission Critical Systems, especially Sections 5.1 and 5.20.
   Note 2: The definitions and terms used in this template are consistent with those in (ISO/IEC 15939).
   Note 3: The definitions and terms used in this template are consistent with those in the Software Measurement Standard (SMS).
   Note 4: Additional guidance is provided in the Software Measurement Standard (SMS).

Purpose: The Software Measurement Plan (SMP) is an integrated plan covering the software development measurement activities for all *software team members* throughout the system development. The SMP provides the planned metrics and their aggregation levels, explanations of computation, expected or projected values, thresholds, and any planned corrective actions to be taken in case thresholds are breached.

References

(ISO/IEC 15939) International Organization for Standards/International Electrotechnical Commission (ISO/ IEC), *Systems and Software Engineering – Measurement Process,* ISO/IEC 15939:2007, 1 August 2007.

(SMS) Abelson, L. A., S. Eslinger, M. C. Gechman, C. H. Ledoux, M. V. Lieu, K. Korzac, *Software Measurement Standard for Mission Critical Systems*, Aerospace Report No. TOR-2009(8506)-6, 5 May 2011, The Aerospace Corporation.

(SDSMCS) Adams, R. J., S. Eslinger, K. L. Owens, J. M. Tagami, and M. A. Zambrana, *Software Development Standard for Mission Critical Systems (SDSMCS)*, Aerospace Report No. TR-RS-2015-00012, March 17, 2014, The Aerospace Corporation. This is the same as SMC Standard SMC-S-012, *Software Development Standard*.

Content Requirements

This template contains the required content of the Software Measurement Plan (SMP). See Section 3 of the Software Development Standard for Mission Critical Systems (SDSMCS) for definitions of all italicized words or phrases.

1. Scope. This section **shall** be divided into the following paragraphs.

1.1 Identification. This paragraph **shall** contain a full identification of the *system* and the *software* to which this *document* applies, including, as *applicable*, identification number(s), title(s), abbreviation(s), version number(s), and release number(s).

1.2 System overview. This paragraph **shall** briefly state the purpose of the *system* and the *software* to which this *document* applies. It **shall**: a) describe the general nature of the *system* and *software*; b) summarize the history of system development, operation, and maintenance; c) identify the project

sponsor, *acquirer*, *user*, *developer*, and support organizations; and d) identify current and planned operating and *user sites*.

1.3 Document overview. This paragraph **shall** summarize the purpose and contents of this *document*. This paragraph **shall** summarize the role of the SMP in the project's measurement process. This paragraph **shall** describe any *security* or privacy considerations associated with its use.

1.4 Relationship to other plans and documents. This paragraph **shall** describe the relationship, if any, of the SMP to the SDP and other project plans and *documents*.

2. Referenced documents. This section **shall** list the number, title, revision, and date of all *documents* referenced in this plan. This section **shall** also identify the source for all *documents* not available through normal Government stocking activities.

3. Project measurement description. This section **shall** be divided into the following paragraphs.

3.1 Project measurement characteristics. This paragraph **shall**:

a. Identify the project team responsible for implementing the measurement plan, including the *prime contractor* and other *software team members*;
b. Depict and describe the organizational structure to be used for measurement, including all organizations, their relationships to one another, the authority and responsibility of each for carrying out required activities, and points of contact for each. This paragraph shall reference relevant documents with citations; and
c. Identify current and planned operations, maintenance, and *user sites*.

3.2 Measurement management characteristics. This paragraph **shall** briefly state:

a. The management review hierarchy for the measurement data;
b. The management reporting systems, i.e., tools and reports, that contain measurement data; and
c. The approval sequencing for all measurement data.

3.3 Project measurement approach. This paragraph **shall** be divided into paragraphs as needed to *establish* the context for the planning described in later sections. It **shall** include, as *applicable*, an overview of:

a. How measurement is integrated into the technical and management *processes*;
b. How system, software, and hardware measurements are related;
c. How data will be collected and used;
d. Measurement points of contact, i.e., *prime contractor* and other *software team members*;
e. Measurement roles, responsibilities, and resources;
f. Communication interfaces between project metrics personnel and organizational metrics personnel;
g. Implementation of the measurement approach, address *builds* and their associated lifecycle activities, if *applicable*;
h. Tools and *databases* to be used for the measurement *process*;
i. Configuration management of the measurement process and data, including addressing how measures are added, modified, or deleted for future reports; and
j. Evaluation criteria for the measurement process, measures, and indicators.

3.4 Software identification items. This paragraph **shall** provide the software identification items specified in the Software Identification Items paragraph of (SMS).

4. Measurement description. This section **shall** be divided into the following paragraphs. Provisions corresponding to nonrequired activities may be satisfied by the words "Not applicable." If different *builds,* different *software items*, different part of the *software items*, or different types or *categories of software* on the project require different planning, then these differences **shall** be noted in the paragraphs. In addition to the content specified below, each paragraph **shall** identify *applicable risks* and uncertainties and the plans for dealing with them.

4.1 Software measurement process. This paragraph **shall** describe the *process* to be used for measurement data collection and reporting throughout the system development lifecycle. This paragraph **shall** describe the *software development lifecycle model(s*) to be used, including: a) planned *builds*, if *applicable*, b) their *build* objectives, and c) the software measurements to be collected in each *build*.

4.2 General requirements. This paragraph **shall** be divided into the following paragraphs.

4.2.1 Measurement goals. This paragraph **shall** be divided into the following subparagraphs.

4.2.1.1 Organizational goals. This paragraph **shall** describe or reference the organizational goals that impact the project's measurement system. This paragraph **shall** discuss any organizational goals for specific process improvement initiatives either currently planned or projected.

4.2.1.2 Project goals. This paragraph **shall** describe or reference the project goals, quantitative or otherwise, that impact the project's measurement system. This paragraph **shall** include any project-specific process improvement initiatives either currently planned or projected.

4.2.1.3 Prioritized goals. This paragraph **shall** itemize the organizational and project goals into a single priority-ordered list.

4.2.2 Recording rationale. This paragraph **shall** describe the approach to be followed for recording rationale for key decisions about software measurements made on the project. This paragraph **shall** interpret the term "key decisions" for the project. The rationale **shall** include tradeoffs considered, analysis methods, and criteria used to make decisions. This paragraph **shall** state where the rationale is to be recorded.

4.2.3 Access for acquirer review. This paragraph **shall** describe the approach to be followed for providing the *acquirer* and its authorized representatives access to *developer* and *software team member* quantitative data about the *products* and activities.

4.2.4 Meeting contractual requirements. This paragraph **shall** describe how the planned software measurement process covers all *contractual requirements* concerning software measurement collection, reporting, *acquirer* team access, management, and related topics.
Note: The exact *contractual requirements* for deliverables are in the *contract*. Those *contractual requirements* state where the software measurement planning information is to be *recorded*. If the software measurement plan is not a deliverable, then the software measurement planning information can be included in Section 5.20 of the SDP or in a separate software measurement plan.

4.2.5 Measurement information specification. This paragraph **shall** contain the measurement information need description for each measure that is identified for use on the project. See

Measurement Information Specification Information Need table of the (SMS) for more information. This paragraph **shall** be divided into the following subparagraphs. The subsequent subparagraphs (4.2.5.x below) specify high level information about each measure. For each measure identified for use on the project, this paragraph **shall** provide:

4.2.5.x Measure name. This paragraph **shall** be divided into the following subparagraphs to describe the identified measure. Provisions corresponding to nonrequired activities *may* be satisfied by the words "Not applicable."

a. Information need. What the measurement user (e.g., manager or project team member) needs to know in order to make informed decisions.
b. Information category. A logical grouping of information needs provided as structure of the measurements. The information category **shall** be one of the following: schedule and progress, resources and costs, product size and stability, product quality, and development performance.
c. Measurable concept. An idea for satisfying the information need by defining the data to be measured.
d. Relevant entities. The object that is to be measured. Entities include process or product elements of a project such as project tasks, plans, estimates, resources, and deliverables.
e. Base measure(s). The property or characteristic of the data that is quantified.
f. Derived measure(s). A measure that is calculated as a function of two or more base measures or other derived measures, to obtain a derived measure.
g. Prioritized goals. The list of prioritized goals, i.e., specified in Paragraph 4.2.1.3 above, to which this measure responds.

Note: Section 5 below requires detailed specifications for each indicator, base measure, and derived measure that support the measures in Paragraph 4.2.5.

5. Software measures. This section **shall** describe the measures to be used for software measurement throughout the system development lifecycle. This section **shall** also include the specific software measures to be used, i.e., collected, interpreted, analyzed, applied, reported, and used for decisionmaking, corrective actions, and reporting to the *acquirer*. This section **shall** specify which measures will be reported by lifecycle activity (e.g., *requirements*, *design*, code, integration, *test*). This section **shall** be divided into the following paragraphs. Provisions corresponding to nonrequired activities may be satisfied by the words "Not applicable." For each measure, i.e., specified in Paragraph 4.2.5 above, selected for use on the project, this section **shall** provide:

5.1 Indicator specifications. This paragraph **shall** be divided into the following subparagraphs. For each measurement information specification identified in Paragraph 4.2.5 above, include at least one of the following:

5.1.x Indicator name. This paragraph **shall** be divided into the following subparagraphs to describe the identified indicator. The measurement information specification, i.e., specified in Paragraph 4.2.5 above, to which this indicator responds **shall** be identified.

a. Indicator description. A text discussion of how one or more measures are used to support the creation of information necessary for analysis and decision making. An indicator is often displayed as a graph or chart.
b. Example indicator diagram. A sketch of the indicator diagram incorporating sample data. This subparagraph **shall** provide a description of how the example indicator diagram is to be interpreted.

c. Analysis model. A defined process that applies decision criteria to characterize the positive or negative behavior of the indicator. If decision criteria are specified, then this field describes their use.
d. Decision criteria. A project performance threshold that delineates positive indicator behavior from negative indicator behavior. A defined set of actions that will be taken in response to specific values of the indicator. This paragraph **shall** define the responses of the measurement user to the indicator.
e. Frequency of data analysis. Identify how often the indicator is reported. This *may* be less frequently than it is collected.
f. Responsible organization. Identify the organization assigned to analyze the indicator and report the results.
g. Phase of analysis. Identify the phases or activities when the indicator is analyzed.
h. Source of data for analysis. Identify sources of data used in the indicator analysis.
i. Tools used in analysis. Identify any tools used for indicator analysis (e.g., statistical tools).
j. User(s) of analysis. Identify the *users* of the indicator results.
k. Additional analysis guidance. Any additional guidance on variations of this measure.
l. Implementation considerations. Any process or implementation *requirements* that are necessary for successful implementation.

5.2 Base measure specification. This paragraph **shall** be divided into the following subparagraphs. For each base measure identified in Paragraph 4.2.5 above include:

5.2.x Base measure name. This paragraph **shall** be divided into the following subparagraphs to describe the identified base measure.

a. Measurement method. The logical sequence of operations that define the counting rules to collect the base measure.
b. Type of method. The type of method used to quantify the base measure, either (1) subjective, involving human judgment, or (2) objective, using only established rules to determine numerical values.
c. Scale. The ordered set of values or categories used to define the base measure.
d. Type of scale. The type of the relationship between values on the scale, either: Nominal, Ordinal, Interval, or Range.
   Note: See Measurement Information Specification Base Measure Specification table in (SMS) for more information.
e. Unit of measure. The standardized quantitative amount that is counted to assign value to the base measure. If tailoring is performed, the *developer* **shall** document the conversion factors between the expected standard value and the *developer's* tailored value. See the Measurement Tailoring paragraph of (SMS).
   Note: The *developer may* tailor the base measure collection and the derived measure calculations specified in the (SMS) standard, where this tailoring is limited to the use of different units of measure (UOMs) for base or derived measures.
f. Frequency of collection. Identify how often the data described by the base measure is collected.
g. Responsible organization. Identify the organization assigned to collect the base measure.
h. Phase of collection. Identify the phases or activities when the base measure is collected.
i. Tools used in collection. Identify any tools used to collect the base measure (e.g., *source code* analyzer).
j. Verification and validation. Identify any verification and validation activities (e.g., *tests*) that will be executed to verify that the base measure is complete and accurate.

5.3 Derived measure specification. This paragraph **shall** be divided into the following subparagraphs. For each derived measure identified in paragraph 4.2.5 above, include:

5.3.x Derived measure name. This paragraph **shall** be divided into the following subparagraphs to describe the identified derived measure.

a. Measurement function. The formula used to calculate the derived measure.
b. Scale. The ordered set of values or categories for each base measure used in the derived measure function. Valid mathematical functions are limited by base measure scale.
c. Type of scale. The type of the relationship between values on the scale for the resulting derived measure, either: Nominal, Ordinal, Interval, or Range.
d. Unit of measure. The standardized quantitative amount of the resulting derived measure. If tailoring is performed, the *developer* **shall** *document* the conversion factors between the expected standard value and the *developer's* tailored value. See the Measurement Tailoring paragraph of (SMS).
   Note: The developer may tailor the base measure collection and the derived measure calculations specified in the (SMS) standard, where this tailoring is limited to the use of different units of measure (UOMs) for base or derived measures.
e. Frequency of calculation. Identify how often the derived measure function is calculated.
f. Responsible organization. Identify the organization assigned to perform the derived measure function calculation.
g. Phase of collection. Identify the phases or activities in which the derived measure function calculation occurs.
h. Tools used in calculation. Identify any tools used for the derived measure function calculation.
i. Verification and validation. Identify any verification and validation activities (e.g., *tests*) that will be executed to verify that the derived measure function calculation is complete and accurate.

6. Measurement indicator reporting and aggregation structures. This section **shall** be divided into the following paragraphs. Provisions corresponding to nonrequired activities *may* be satisfied by the words "Not applicable."

6.1 Report aggregation. Measures reported *may* be aggregated to higher levels of aggregation using specific mathematical functions. Aggregation *may* occur up through product integration, e.g., to *builds*, *software items*, or any other *applicable* aggregation scheme. This paragraph **shall** identify the indicators, base measures, and derived measures from paragraph 5 above for which aggregation will be performed and reported. This paragraph **shall** specify which measures will be aggregated for each *build* and *software item*. See the Software Measurement Aggregation Considerations paragraph in (SMS) for more information on aggregation. For each indicator, base measure, and derived measure for which aggregation is to be performed, this paragraph **shall** provide:

6.1.1 Aggregated measures. This paragraph **shall** be divided into the following subparagraph to describe each identified aggregated measure.

6.1.1.x Aggregated measure name. This paragraph **shall** be divided into the following subparagraphs to describe the identified aggregated measure.

a. Measurement function. The formula used to calculate the aggregated measure.
b. Scale. The ordered set of values or categories for each base or derived measure used in the aggregated measure function. Valid mathematical functions are limited by base and derived measure scales.

c. Type of scale. The type of the relationship between values on the scale for the resulting derived measure, either: Nominal, Ordinal, Interval, or Range.
d. Unit of measure. The standardized quantitative amount of the resulting aggregated measure.
e. Frequency of calculation. Identify how often the aggregated measure function is calculated.
f. Responsible organization. Identify the organization assigned to perform the aggregated measure function calculation.
g. Phase of collection. Identify the phases or activities when the aggregated measure function calculation occurs.
h. Tools used in calculation. Identify any tools used in the aggregated measure function calculation.
i. Verification and validation. Identify any verification and validation activities (e.g., *tests*) that will be executed to verify that the aggregated measure function calculation is complete and accurate.

6.2 Build aggregated measures. This paragraph **shall** specify the aggregated measure names, i.e., specified in Paragraph 6.1.1 above, which will be aggregated for each *build*. If there are any differences in the aggregated measures between *builds*, then this paragraph **shall** specify the differences.

6.3 Software item aggregated measures. This paragraph **shall** specify the aggregated measure names, i.e., specified in Paragraph 6.1.1 above, which will be aggregated for each *software item*. If there are any differences in the aggregated measures between *software items*, then this paragraph **shall** specify the differences.

6.4 Reporting. This paragraph **shall** specify: a) the planned contents of measurement reports, b) frequency of measurement reports, c) planned delivery mechanism(s), i.e., electronic and human-readable), and d) planned recipients of the reports. This paragraph **shall** specify for each *software item (SI)* and *build* how the following four items will be reported electronically. See the Measurement Data Electronic Reporting paragraph of (SMS). This paragraph **shall** also specify for each *software item (SI)* and *build* how the measurement diagrams and analyses of the measurement data will be reported in human-readable form. See the Measurement Data Human-Readable Reporting paragraph of (SMS). This paragraph **shall** also specify the aggregated measurements to be reported: a) electronically, and b) in human-readable form. The aggregated measurements to be reported **shall** include:

a. Project characteristic data. All project characteristics, as specified in the Project Characteristics paragraph of (SMS).
b. Base measures. All base measures, as specified in the Base Measure Specifications appendix of (SMS), with tailored UOMs provided.
c. Derived measures. All derived measures, as specified in the Derived Measure Specifications appendix of (SMS), with tailored UOMs provided.
d. Identification items. All identification items, as specified in the Software Identification Items paragraph of (SMS).

7. Notes. This section **shall** contain any general information that aids in understanding this *document* (e.g., background information, glossary, rationale). This section **shall** be divided into the following paragraphs.

7.1 Abbreviations and acronyms. This paragraph **shall** include an alphabetical listing of all acronyms, abbreviations, and their meanings as used in this *document*.

7.2 Glossary. This paragraph **shall** include a list of any terms and their definitions needed to understand this *document*. Terms often used differently between organizations (e.g., acquisition phase names, *build*, block, development phase names, effectivity, evolution, increment, and iteration) **shall** be defined to avoid confusion. If the terms used are exactly as defined in the Software Development Standard (SDSMCS) and Software Measurement Standard (SMS), they need not be redefined here.

7.3 General information. This paragraph **shall** contain any other general information that aids in understanding this *document* (e.g., background information, rationale).

A. Appendices. Appendices may be used to provide information published separately for convenience in document maintenance (e.g., charts, classified data). As *applicable*, each appendix **shall** be referenced in the main body of the *document* where the data would normally have been provided. Appendices may be bound as separate *documents* for ease in handling. Appendices **shall** be lettered alphabetically (A, B, etc.).

END of SMP Template

H.5 Software Measurement Report (SMR) Template

This appendix is a MANDATORY part of the (SDSMCS). It provides the content *requirements* for the SMR.

1. If the section numbering used below is not used, the *developer* **shall** provide an appendix in the SMR with a traceability matrix mapping from the section numbers and titles below to the section numbers and titles used in the developer SMR.
2. If there is such a traceability mapping appendix, it **shall** be referenced in Section 1.3.
   Note 1: The information shown below is consistent with the Software Development Standard for Mission Critical Systems (SDSMCS), especially Sections 5.1 and 5.20.
   Note 2: The software measurement report (SMR) definitions and terms used below are consistent with those in the Software Measurement Standard (SMS).

Purpose: Each Software Measurement Report (SMR) is an integrated report covering the software development activities for all significant *software team members* throughout the system development. The SMR provides explanations and interpretations of reported measurement data, including deviations from expected or projected values and breaches of thresholds as well as any corrective actions being undertaken. The software measurements collected and reported each month are expected to vary because the lifecycle activities vary over time.

References

(CMMI) Software Engineering Institute, *Capability Maturity Model Integration, Version 1.3, CMMI for Development*, Report No. CMU/SEI-2010-TR-033, November 2010, Software Engineering Institute, Carnegie Mellon University. Capability Maturity Model® and CMMI® are registered in the U. S. Patent and Trademark Office by Carnegie Mellon University.

(SMS) Abelson, L. A., S. Eslinger, M. C. Gechman, C. H. Ledoux, M. V. Lieu, K. Korzac, *Software Measurement Standard for Space Systems*, Aerospace Report No. TOR-2009(8506)-6, 5 May 2011, The Aerospace Corporation.

(SDSMCS) Adams, R. J., S. Eslinger, K. L. Owens, J. M. Tagami, and M. A. Zambrana, *Software Development Standard for Mission Critical Systems (SDSMCS)*, Aerospace Report No. TR-RS-2015-00012, March 17, 2014, The Aerospace Corporation. This is the same as SMC Standard SMC-S-012, *Software Development Standard*.

Content Requirements

This template contains the required content of the Software Measurement Report (SMR). See Section 3 of the Software Development Standard for Mission Critical Systems (SDSMCS) for definitions of all italicized words or phrases.

1. Scope. This section **shall** be divided into the following paragraphs.

1.1 Identification. This paragraph **shall** contain a full identification of the *system* and the *software* to which this *document* applies, including, as *applicable*, identification number(s), title(s), abbreviation(s), version number(s), and release number(s). This paragraph **shall** provide the period of reporting.

1.2 System overview. This paragraph **shall** briefly state the purpose of the *system* and the *software* to which this *document* applies. It **shall**: a) describe the general nature of the *system* and *software*; b) summarize the history of *system* development, operation, and maintenance; c) identify the project

sponsor, *acquirer*, *user*, *developer*, and support organizations; and d) identify current and planned operating and *user sites*.

1.3 Document overview. This paragraph **shall** summarize the purpose and contents of this *document*. This paragraph **shall** describe any *security* or privacy considerations associated with its use.

1.4 Relationship to other documents and plans. This paragraph **shall** describe the relationship, if any, of the SMR to the Software Development Plan (SDP), software measurement plan, and other project management plans.

2. Referenced documents. This section **shall** list the number, title, revision, and date of all *documents* referenced in this plan. This section **shall** also identify the source for all *documents* not available through normal Government stocking activities.

3. Metrics analysis summary. This section **shall** be divided into the following paragraphs.

3.1 Contract milestones. This paragraph **shall** identify significant project milestones for the next six months.

3.2 Measurement performance. This paragraph **shall** summarize measurement performance highlights that are detailed in the subsequent report. When a threshold identified in the Software Measurement Plan (SMP) is breached, then mitigation planning **shall** be itemized in this section.

4. General requirements. This section **shall** be divided into the following paragraphs. Provisions corresponding to nonrequired activities may be satisfied by the words "Not applicable." If different *builds* or different *software* on the project require different planning, these differences **shall** be noted in the paragraphs.

4.1 Project build and software item characteristics. For each *build* and *software item* (*SI*), this paragraph **shall** provide the context information specified in the Project Characteristics paragraph of the Software Measurement Standard (SMS):

a. Computer resource characterization;
   (1) Computer hardware identification;
   (2) Computer communication identification;
   (3) Computer storage hardware identification;
b. Authorizing agreement (e.g., Memorandum of Understanding (MOU), contract, amendment);
c. Development organization(s);
d. Capability Maturity Model Integration for Development (CMMI®-DEV) maturity level;
e. Application type;
f. Development *process*;
g. Software origin;
h. Computer language;
i. *Reusable software* applications, including *COTS* and *acquirer*-furnished *software*.

4.1.x Build x <Insert Name> characteristics. For each *build* "x," this paragraph **shall** provide the context information specified in paragraph 4.1 above. If any of these characteristics changes, then this paragraph **shall** highlight the change(s).

4.1.x.y Software item x.y <Insert Name> characteristics. For each *software item* (*SI*) "y" in the *build,* this paragraph **shall** provide the context information specified in paragraph 4.1 above. If any of these characteristics changes, then this paragraph **shall** highlight the change(s).

4.2 Identification items. For each *build* and *SI*, this paragraph **shall** provide the identification information specified in the Software Identification Items paragraph of (SMS):

a. WBS element identifier;
b. Control account;
c. Integrated master schedule (IMS);
d. Specification tree identification number;
e. Component identification;
f. Acquisition phase identification;
g. Development phase identification;
h. System identification (version and release);
i. Subsystem identification (version and release);
j. Element identification (version and release);
k. Software item identification (version and release);
l. Build identification (Release);
m. Computer resource utilization (CPU):
    (1) CPU identification(s) (ID(s));
    (2) Computer resource utilization input/output ID;
    (3) Computer resource utilization memory storage device;
n. Computer resource utilization response time.

4.2.x Build x <Insert Name> identification items. For each *build,* this paragraph **shall** provide the context information specified in paragraph 4.2 above. If any of these characteristics changes, then this paragraph **shall** highlight the change(s).

4.2.x.y Software item x.y <Insert Name> identification items. For each *SI* in the *build,* this paragraph **shall** provide the context information specified in paragraph 4.2 above. If any of these characteristics changes, then this paragraph **shall** highlight the change(s).

5. Measurement data human-readable reporting. This section **shall** report the data by the particular component, e.g., *build*, increment, or evolution, to which they apply. In addition, this section **shall** report the data by the SI to which they apply. This section **shall** be divided into the following paragraphs. Provisions corresponding to nonrequired activities may be satisfied by the words "Not applicable." For each measurement diagram whenever a tailored Unit of Measure (UOM) is used, a footnote or other appropriate notation **shall** *document* that fact. For each measurement diagram, the subsections **shall** provide the following labeling information specified in the Measurement Diagram Content and Labeling paragraph of (SMS):
    a. Scope of the data;
    b. *SI* or *build* name;
    c. Product integration level;
    d. Reporting period;
    e. Reported by.

5.x Build identifier. Identify the specific component, e.g., *build*, increment, or evolution, to which each of the subsequent measurements apply. This paragraph, including each of its sub-items and its aggregated data (5.x.y through 5.x.y+1), **shall** be repeated for each *build* "x."

5.x.y Software item identifier. Identify the specific *software item* (*SI*) to which each of the subsequent measurements apply. In addition to the content specified below, each paragraph **shall** identify *applicable risks* and uncertainties and the plans for dealing with them. This paragraph, including each of its sub-items and its aggregated data (5.x.y through 5.x.y.18, where ".x" is the *build* and ".y" is the *software item*) **shall** be repeated for each *software item* "y."

5.x.y.1 Requirement progress management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of requirement progress. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Requirements progress management paragraph:

a. Requirements defined
b. Requirements TBX closure
c. Requirements verified
d. Qualification methods

5.x.y.2 Development progress management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of development progress. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Development progress management paragraph:

a. Components defined
b. Units defined
c. Units coded and unit tested
d. Units integrated and tested

5.x.y.3 Test progress management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of test progress. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Test progress management paragraph:

a. Test cases developed
b. Test cases dry run
c. Test cases performed
d. Test cases passed

5.x.y.4 Schedule adherence management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of schedule adherence. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Schedule adherence management paragraph:

a. Project milestones
b. Scheduled activities

5.x.y.5 Effort profile management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of effort profile management. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Effort profile management paragraph:

a. Labor hours
b. Rework labor hours

5.x.y.6 Staff profile management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of staff profile management. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Staff profile management paragraph:

a. Staffing level
b. Staff by experience
c. Staff turnover

5.x.y.7 Computer resource management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of computer resource management. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Computer resource management paragraph:

a. CPU utilization
b. Memory utilization
c. Input/output utilization
d. Response time

5.x.y.8 Cost profile management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of cost profile management. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Cost profile management paragraph:

a. Earned value performance
b. Schedule and cost performance index
c. Schedule and cost variance

5.x.y.9 Size management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of size management. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Size management paragraph:

a. Requirements size
b. Requirements by type
c. Line of code size
d. Line of code by origin
e. Line of code by type

5.x.y.10 Volatility management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of volatility management. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Volatility management paragraph:

a. Requirement volatility
b. Line of code volatility

5.x.y.11 Build content management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base measures of build content management. For the current reporting period, plot and report base measures in accordance with the instructions provided in the (SMS) Build content management paragraph:

a. Requirements per *build*

5.x.y.12 Defect resolution management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of defect

resolution management. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Defect resolution management paragraph:

a. Discrepancy report status
b. Discrepancy report aging
c. Discrepancy report by type
d. Discrepancy report by source

5.x.y.13 Complexity management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base measures of complexity management. For the current reporting period, plot and report the base measure in accordance with the instructions provided in the (SMS) Complexity management paragraph:

a. Cyclomatic complexity

5.x.y.14 Coverage management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of coverage management. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Coverage management paragraph:

a. Requirements to design traceability
b. Requirements to test traceability

5.x.y.15 Productivity management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of productivity management. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Productivity management paragraph:

a. Development productivity

5.x.y.16 Maturity management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of maturity management. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Maturity management paragraph:

a. Development defect density

5.x.y.17 Management status management indicator. For the current reporting period, this paragraph **shall** provide in tabular and graphic form the following base and derived measures of management status. For the current reporting period, plot and report base and derived measures in accordance with the instructions provided in the (SMS) Management status paragraph:

a. Action item closure
b. Risk mitigation task Completion Status
c. Schedule compression

5.x.y.18 Aggregated measurement report (SI level). For the current reporting period, this paragraph **shall** report any aggregated measurements identified for the project as specified in the project software measurement plan (SMP) for the *software item* (*SI*). This information **shall** be reported for each paragraph 5.x.y *SI* after all of the other measurements for that *SI*.

5.x.y+1 Aggregated measurement report (build level). For the current reporting period, this paragraph **shall** report any aggregated measurements identified for the project as specified in the project software measurement plan (SMP) for the *build*. This information **shall** be reported for each paragraph 5.x *build* after all of the other measurements of the *software items* for that *build*.

6. Measurement data electronic reporting. This section **shall** specify the electronic reporting of measurement data. This section **shall** be divided into the following paragraphs.

6.1 Base measures. In accordance with the data definitions provided in (SMS) Appendix A, Base Measure Specifications, this paragraph **shall** provide the planned base measure data. For the current reporting period, this paragraph **shall** provide actual base measure counts in accordance with the data definition provided in (SMS) the Base Measure Specifications appendix.

6.2 Derived measures. For the current reporting period, this paragraph **shall** report the calculated derived values in accordance with the data definition provided in (SMS) the Derived Measure Specifications appendix.

6.3 Aggregated measurement report. Report any aggregated measurements identified for the project as specified in the project software measurement plan (SMP).

7. Notes. This section **shall** contain any general information that aids in understanding this *document* (e.g., background information, glossary, rationale). This section **shall** be divided into the following paragraphs.

7.1 Abbreviations and acronyms. This paragraph **shall** include an alphabetical listing of all acronyms, abbreviations, and their meanings as used in this *document*.

7.2 Glossary. This paragraph **shall** include a list of any terms and their definitions needed to understand this *document*. Terms often used differently between organizations (e.g., acquisition phase names, *build*, block, development phase names, effectivity, evolution, increment, and iteration) **shall** be defined to avoid confusion. If the terms used are exactly as defined in the Software Development Standard (SDSMCS) and Software Measurement Standard (SMS), they need not be redefined here.

7.3 General information. This paragraph **shall** contain any other general information that aids in understanding this *document* (e.g., background information, rationale).

A. Appendices. Appendices may be used to provide information published separately for convenience in document maintenance (e.g., charts, classified data). As *applicable*, each appendix **shall** be referenced in the main body of the *document* where the data would normally have been provided. Appendices may be bound as separate *documents* for ease in handling. Appendices **shall** be lettered alphabetically (A, B, etc.).

END of SMR Template

H.6 Process Improvement Plan (PIP) Template

This appendix is a MANDATORY part of the (SDSMCS). It provides the content *requirements* for the Process Improvement Plan (PIP).

1. If the section numbering used below is not used, the *developer* **shall** provide an appendix in the PIP with a traceability matrix mapping from the section numbers and titles in the PIP template below to the section numbers and titles used in the developer PIP.
2. If there is such a traceability mapping appendix, it **shall** be referenced in Section 1.3.

   Note 1: The information below is consistent with the Software Development Standard for Mission Critical Systems (SDSMCS), especially Section 5.25.

Purpose: The PIP is an integrated plan covering the software development process improvement activities for all *software team members* throughout the system development life cycle. The PIP provides the plans and activities to improve the *processes* on the project based on process assessments conducted by the *acquirer* team or the *developer* team or both.

References

(CMMI) Software Engineering Institute, *Capability Maturity Model Integration, Version 1.3, CMMI for Development*, Report No. CMU/SEI-2010-TR-033, November 2010, Software Engineering Institute, Carnegie Mellon University. Capability Maturity Model® and CMMI® are registered in the U. S. Patent and Trademark Office by Carnegie Mellon University.

(SDSMCS) Adams, R. J., S. Eslinger, K. L. Owens, J. M. Tagami, and M. A. Zambrana, *Software Development Standard for Mission Critical Systems (SDSMCS)*, Aerospace Report No. TR-RS-2015-00012,March 17, 2014, The Aerospace Corporation. This is the same as SMC Standard SMC-S-012, *Software Development Standard*.

Content Requirements

This template contains the required content of the PIP. See Section 3 of the Software Development Standard for Mission Critical Systems (SDSMCS) for definitions of all italicized words or phrases.

1. Scope. This section **shall** be divided into the following paragraphs.

1.1 Identification. This paragraph **shall** contain a full identification of the *system* and the *software* to which this *document* applies, including, as *applicable*, identification number(s), title(s), abbreviation(s), version number(s), and release number(s).

1.2 System overview. This paragraph **shall** briefly state the purpose of the *system* and the *software* to which this *document* applies. This paragraph **shall**: a) describe the general nature of the *system* and *software*; b) summarize the history of *system* development, operation, and maintenance; c) identify the project sponsor, *acquirer*, *user*, *developer*, and support organizations; and d) identify current and planned operating and *user sites*.

1.3 Document overview. This paragraph **shall** summarize the purpose and contents of this *document*. This paragraph **shall** describe any *security* or privacy considerations associated with its use.

1.4 Relationship to other documents and plans. This paragraph **shall** describe the relationship, if any, of the PIP to the software development plan, software measurement plan, and other project management plans.

2. Referenced documents. This section **shall** list the number, title, revision, and date of all *documents* referenced in this plan. This section **shall** also identify the source for all *documents* not available through normal Government stocking activities.

3. Process improvement background. This section **shall** provide background on the project's *processes* and process improvement efforts.

3.1 Process baselines. This paragraph **shall** include the *process* title, *process* identifier, organization site, and date of each *process* in each identified baseline below:

a. Identified process baseline(s) from which process improvements are to be made; and
b. Identified process baseline(s) of each *software team member,* if any, that use different *processes* from those defined for the project or levied by the *prime contractor* on the other *software team members*.

3.2 Process appraisal results. For each process appraisal or process audit performed on the project on any member of the *developer* team, including the *prime contractor* and other *software team members,* this paragraph **shall** include:

a. Results including dates, detailed final findings, and whether from project self-appraisal(s), acquirer appraisal(s), or combined acquirer and developer appraisal team(s);
b. The appraisal disclosure statements (ADSs) and any additional clarifying materials from all SCAMPIs[8], if any, performed; and
c. The current resolution status of the findings.

3.3 Previous process improvements. This paragraph **shall** include:

a. Descriptions of previous *process* improvement efforts that have been performed on the project;
b. Other process improvement efforts, if any, that apply to the project;
c. Any additional clarifying information related to process improvement;
d. The project's process improvements implemented so far; and
e. List of process improvement artifacts.

4. Process improvement goals and success criteria. This paragraph **shall**:

a. Identify the goals and objectives for process improvement;
b. Describe the project's planned process improvements;
c. Define the process improvement task success criteria;
d. Define how these criteria are measured;
e. Identify process improvement measurements; and
f. For the project *software team members,* if any, that are part of CMMI® high maturity organizations[9], identify the quantitative success criteria for evaluating the results.[10]

---

[8]Standard CMMI Appraisal Method for Process Improvement (SCAMPI(SM))

[9]High-maturity organizations are appraised by an *Appraisal Requirements for CMMI* (ARC) Class A SCAMPI appraisal as practicing and successfully rated by an independent CMMI Institute-certified High Maturity Lead Appraiser, as Maturity Level 4 or 5, including all 20 or 22 CMMI-DEV V1.3 process areas, respectively. The Level 4 CMMI high-maturity process areas are: Organizational Process Performance (OPP) and Quantitative Project Management (QPM); the Level 5 process areas are: Causal Analysis and Resolution (CAR) and Organizational Performance Management (OPM).

[10]CMMI® and SCAMPI(SM) are a trademark and service mark of Carnegie Mellon University.

5. Project process improvement organization. This section **shall** depict and describe the organizational structure to be used for process improvement on the project.
   Note: Reference Section 7.1 of the SDP for the project organization.

5.1 Process improvement groups. This paragraph **shall**:
   a. Describe the project's process improvement groups, i.e., the enduring groups;
   b. Describe the process action teams, i.e., short-duration teams for developing or improving specific *processes*;
   c. Provide charters that identify the focus of the activities and the responsibilities for each process improvement group and process action team.

5.2 Process improvement processes and procedures. This paragraph **shall**:
   a. Include the *processes* and procedures to be used to manage the project's process improvement activities;
   b. Identify the checklists, templates, and work instructions for performing and managing the improvement tasks and generating the resulting *work products*;
   c. Identify the necessary management, development, and support activities for process improvement; and
   d. Identify the planned process improvement *work products*.

5.3 Project process architecture. This paragraph **shall** provide the process architecture across the *prime contractor* and all *software team members.* It shall include inputs, outputs, sequencing, interfaces, interdependencies, and other relationships between the *processes* and procedures in the project's defined *process*es and any other relevant processes (e.g., corporate *processes*).

6. Process improvement planning. This section **shall** describe the planning of the process improvement activities. The process improvement planning **shall**:
   a. Include any other inputs, besides the findings in Paragraph 3.2, to the process improvement plan (e.g., lessons learned, process effectiveness measures);
   b. Describe the process improvement activities that address the findings;
   c. Identify any 1) barriers and *risks* to implementing this plan, and 2) the risk management strategy appropriate for each of them;
   d. Describe how this process improvement plan will be applied to the *software team members* performing *software development* on the project; and
   e. Specify the effort, budget, schedule, and other resources for the process improvement activities, including the basis of estimates and assumptions made.

7. Process improvement implementation and tracking. This section **shall** describe the steps to be followed in:
   a. Implementing this plan;
   b. Tracking progress against this plan; and
   c. Measuring the effectiveness of the process improvement activities, including measurements and quality assurance activities.

8. Notes. This section **shall** contain any general information that aids in understanding this *document* (e.g., background information, glossary, rationale). This section **shall** be divided into the following paragraphs.

8.1 Abbreviations and acronyms. This paragraph **shall** include an alphabetical listing of all acronyms, abbreviations, and their meanings as used in this *document*.

8.2 Glossary. This paragraph **shall** include a list of any terms and their definitions needed to understand this *document*. Terms often used differently between organizations (e.g., acquisition phase names, *build*, block, development phase names, effectivity, evolution, increment, and iteration) **shall** be defined to avoid confusion. If the terms used are exactly as defined in the Software Development Standard (SDSMCS), they need not be redefined here.

8.3 General information. This paragraph **shall** contain any other general information that aids in understanding this *document* (e.g., background information, rationale).

A. Appendices. Appendices may be used to provide information published separately for convenience in *document* maintenance (e.g., charts, classified data). As *applicable*, each appendix **shall** be referenced in the main body of the *document* where the data would normally have been provided. Appendices may be bound as separate *documents* for ease in handling. Appendices **shall** be lettered alphabetically (A, B, etc.).

SMC Standard Improvement Proposal

INSTRUCTIONS

1. Complete blocks 1 through 7. All blocks must be completed.
2. Send to the Preparing Activity specified in block 8.

NOTE: Do not use this form to request copies of documents, or to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements. Comments submitted on this form do not constitute a commitment by the Preparing Activity to implement the suggestion; the Preparing Authority will coordinate a review of the comment and provide disposition to the comment submitter specified in Block 6.

SMC STANDARD CHANGE RECOMMENDATION:	**1. Document Number** SMC-S-012	**2. Document Date** 16 January 2015

3. Document Title	Software Development for Mission Critical Systems

4. Nature of Change
(Identify paragraph number; include proposed revision language and supporting data. Attach extra sheets as needed.)

5. Reason for Recommendation

6. Submitter Information

a. Name	**b. Organization**
c. Address	**d. Telephone**
e. E-mail address	**7. Date Submitted**

8. Preparing Activity	Space and Missile Systems Center AIR FORCE SPACE COMMAND 483 N. Aviation Blvd. El Segundo, CA 91245 Attention: SMC/ENE